Deep REnovation roadmaps to decrease households VulnERability to Energy poveRty

Project No. 101076277

Annex to Deliverable 3.4 - Renovation roadmaps

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Building renovation roadmaps

Annex IX: Roadmap II – Social Single-Family Buildings in Coimbra

Co-funded by the European Union

Executive summary

The REVERTER roadmaps aim to combat energy poverty through the deep renovation of dwellings occupied by vulnerable households. The roadmaps were developed considering the conclusions and policy recommendations that resulted from the analysis of the best practices and the different characteristics and conditions of the targeted countries. To this end, the roadmaps are tailor-made to the characteristics of the building stock, the characteristics of the vulnerable households, the legislative framework, and the climate conditions of each pilot, while they intend to cover a sufficiently cohesive group of cases that will allow for a larger-scale rollout and replication of the proposed actions for the effective analysis and tackling of the problem. Moreover, the roadmaps target the worst-performing homes first (worst first principle) and promote the most cost-effective energy efficiency and RES interventions (best-possible principle) to ensure that the economic, energy, climate, and social benefits triggered by the implementation of the required energy efficiency and RES interventions are maximised.

The present Roadmap II "Social Single-Family Buildings in Coimbra" aims to lead households living in detached houses and are vulnerable to find solutions to improve their comfort levels and reduce their energy bills. The solutions will not focus only on the energy renovation of the building envelope, but also on the advantages of adopting renewable energy sources. More specifically, Roadmap II provides a pathway for local, regional and national authorities to upgrade around 6,700 single-family buildings (SFBs) in the Municipality of Coimbra, by 2050. The abovementioned figures were calculated taking into account the number of SFBs constructed before 2005, and the percentage of energy-poor households in the Municipality of Coimbra (i.e. 17.5%, for details refer to Section 2). To estimate the renovation costs four different renovation schemes were modelled and analysed. The replacement of windows and doors, and the installation of a new heat pump and PV panels had the best performance on the examined indicators, and therefore it was selected for Roadmap II.

Focusing specifically on the renovations triggered by REVERTER (i.e. until the end of the project and 5 years beyond project-end) through the establishment and operation of the physical and digital one-stop shops, visits to homes of energy-poor households by REVERTER Ambassadors, and the awareness-raising and training activities, it is estimated that 9 social SFBs will be retrofitted. The overall impacts of the project are summarised in Table ES1. Since the dwellings are social houses owned by the Municipality, the investment cost will be covered entirely by public funds.

Table ES1. Contribution of the REVERTER project to the implementation of the specific roadmap for the renovation of social SFBs in the period 2025-2030.

Impacts Roadmap I	Energy-poor households - Social single-family buildings (SFB)
Number of newly renovated apartments	9
Resulted cumulative final energy savings (GWh)	0.071
Resulted cumulative primary energy savings (GWh)	0.176
Resulted cumulative CO_2 reduction (ktn CO_2)	0.0107
Resulted employment impacts (person-years)	0.9
Resulted cumulative multiple benefits (million €)	0.0043
Required new investments (million €)	0.059

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1. Introduction

1.1 Analysis of the main objectives of the renovation roadmap

Portugal's commitment to neutralising its emissions by 2050 has led the country to design an ambitious decarbonisation strategy for the national economy. The 2050 Roadmap to Carbon Neutrality was officially approved in 2019 (RCM nº 107/2019) and was implemented through the National Energy and Climate Plan 2030 (RCM nº 53/2020), setting out the policies and measures needed to achieve the targets set for the next decade.

One of the strategic objectives of the PNEC 2030 is to ensure a just, democratic and cohesive transition, strengthening the role of the citizen as an active agent in decarbonisation and the energy transition, creating a level playing field for all, combating energy poverty, creating instruments for the protection of vulnerable citizens and promoting the active involvement of citizens and territorial valorisation. Within this scenario, at the local level, municipalities are deeply motivated to prepare their Climate and Energy Plans, to improve overall citizen´s well-being. Within this context, the Municipality of Coimbra accepted the challenge of preparing two roadmaps for its social housing building stock (Coimbra Municipal Housing Park), the first for social multi-family buildings (MFBs) and the second one for social single-family buildings (SFHs).

The Coimbra Municipal Housing Park consists of 854 dwellings, with different typologies, integrating building apartments and detached houses dispersed over the city. Considering that the phenomenon of energy poverty also affects people living outside social housing, the roadmap applies to all dwellings, social and non-social, occupied by vulnerable households. In such a context, the roadmap presents a complete pathway for renovating the houses of all vulnerable households in Coimbra Municipality. However, the impacts of REVERTER on the target population, i.e. renovations of social housing belonging to the Municipality of Coimbra, are presented separately.

Roadmap II will help vulnerable households living in single-family buildings in social neighbourhoods find solutions towards improving their comfort levels, taking advantage of renewable generation and lowering energy bills. The solutions focus on the building envelope and the installation of renewable energy sources.

1.2 Main energy, environmental and climate change legislative and policy framework at the national level

The main energy, environmental and climate change legislative and policy framework in Portugal is driven and aligned with the European legislation. In 2016, Portugal committed to ensuring the neutrality of its GHG emissions by 2050, setting out a clear vision for the deep decarbonisation of the national economy, as a contribution to the Paris Agreement and in line with ongoing international efforts. To achieve this goal, the National Roadmap to Carbon Neutrality 2050[1] (RNC 2050) was approved by Council of Ministers Resolution no. 107/2019 of 1 July, which is the long-

[1] https://descarbonizar2050.apambiente.pt/

term development strategy with low GHG emissions submitted to the United Nations Framework Convention on Climate Change on 20 September 2019, and which identifies the main vectors for decarbonisation and the lines of action to be pursued towards a carbon-neutral society by 2050.

Among the main vectors of decarbonisation and lines of action for a carbon-neutral society, established within the scope of the RNC 2050, is the promotion of decarbonisation in the residential sector. It favours urban regeneration and increased energy efficiency in buildings, encourages the progressive electrification of the sector and the use of more efficient equipment, and combats energy poverty. Also, it promotes a just and cohesive transition that valorises the territory, creates wealth, promotes employment and contributes to raising standards of quality of life in Portugal.

To realise the policies and measures needed to achieve the goals set for the next decade, in line with the RNC 2050 and in fulfilment of the Regulation (EU) 2018/1999, Portugal submitted the National Energy and Climate Plan 2030 (PNEC 2030) to the European Commission at the end of 2020. The PNEC 2030 is the main energy and climate policy instrument until 2030, and its implementation allows Portugal to commit to the energy transition, which is an unrivalled opportunity for industrialisation and, strengthening energy security, while ensuring affordable and competitive prices. In this context, the Portuguese targets for the 2021-2030 decade were set, such as the reduction of GHG emissions, the incorporation of renewable sources in final energy consumption, reducing external energy dependence and reducing primary energy consumption.

Additionally, in fulfilment of the provisions of Regulation (EU) 2018/1999, Portugal submitted to the Commission, on 30 June 2023, the first revision of the PNEC 2030, reflecting the renewed national ambition in terms of climate and energy policy, aligned with the new European framework. This first working version establishes new targets for reducing GHG emissions, in accordance with the provisions of the climate law (Lei de Bases do Clima), new targets for the incorporation of energy from renewable sources, as well as new measures to be adopted to realise them. The revision reflects the renewed ambition and the government's firm commitment to accelerating the climate and energy transition, energy security and the country's industrialisation, ensuring jobs and green energy at competitive prices.

In order to materialise Portugal's strategic vision and ensure compliance with the goals and objectives set for 2030, eight national objectives were defined, among which the following stand out: "Ensuring a just, democratic and cohesive transition - Strengthening the role of citizens as active agents in decarbonisation and the energy transition, creating a level playing field for all, combating energy poverty, create instruments for the protection of vulnerable citizens and promote the active involvement of citizens and territorial valorisation".

With a view to ensuring this goal, the PNEC 2030 establishes the following lines of action "Fight energy poverty and improve instruments to protect vulnerable customers ", which establishes a set of action measures, including approval of a long-term strategy to combat energy poverty (ELPPE), with a view to improving knowledge of this problem, seeking to integrate responses and create the conditions that motivate a structural change towards its eradication.

This Long-Term Strategy to Combat Energy Poverty 2030-2050 (ELPPE) adopts the definition of energy poverty provided in Directive (EU) 2023/1791 of the European Parliament and of the Council of 13 September on Energy Efficiency, which defines it as "the lack of access by a household to

essential energy services, where such services provide basic and dignified standards of living and health, including adequate heating, hot water, cooling and lighting and the energy needed for household appliances, taking into account the national context, social policy and other relevant national policies, caused by a combination of factors, including at least lack of affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of dwellings".

The targets to be achieved for the main strategic indicators for the 2030s, 2040s and 2050s are set in the ELPPE as follows:

- Households unable to keep the home adequately warm: 10 % in 2030, 5 % in 2040 and < 1 % in 2050 (reference value 17.5 % in 2020);
- Population living in dwellings that are not comfortably cool during the summer: 20 % in 2030, 10 % in 2040 and < 5 % in 2050 (reference value 35.7 % in 2012);
- Population living in dwellings with problems of infiltration, humidity or rotten elements: 20 % in 2030, 10 % in 2040 and < 5 % in 2050 (reference value 25.2 % in 2020);
- Households whose energy expenditure represents + 10% of total income: 700 000 in 2030, 250 000 in 2040 and 0 in 2050 (reference value 1 202 567 households in 2016).

ELPPE's main goal is to eradicate energy poverty in Portugal by 2050, protecting vulnerable consumers and actively integrating them into the energy and climate transition, which is intended to be fair, democratic and cohesive. To reach the objectives, ELPPE is structured around four strategic lines of action:

1. **Promoting the energy and environmental sustainability of housing (EE1). Action along this axis pursues two strategic objectives:**

Increasing the energy efficiency of housing (OE1.1), through the adoption of constructive solutions, rehabilitation and renovation, replacement of old inefficient equipment or adoption of new efficient ones, new materials, technologies and processes, significantly reducing energy needs and increasing comfort.

Decarbonisation of consumption (OE1.2), through the adoption of local renewable energy systems for electricity production and for heating and cooling favouring the electrification of consumption.

2. **Promoting universal access to essential energy services (EE2). Action along this axis pursues two strategic objectives:**

Reduce the number of households having difficulty paying for essential energy services (OE2.1), by implementing instruments to reduce energy bills, either by acting on energy prices or on access to local production of renewable electricity for self-consumption and energy sharing in renewable energy communities.

Ensure the protection of vulnerable consumers in situations of energy poverty (OE2.2), by developing mechanisms to prevent supply interruptions at critical times, as well as instruments that guarantee the provision of minimum services.

3. **Promoting integrated territorial action (EE3). Action along this axis pursues two strategic objectives:**

Strengthen the action of local structures in the fight against energy poverty (OE3.1), by promoting an integrated network of Citizen Energy Spaces with high territorial permeability, providing information, counselling and support services for implementing interventions and the adoption of sustainable energy practices, promoting the integration of combating energy poverty in local public policies, and removing barriers to the development of municipal renewable energy communities.

Strengthen the supply of public housing with high energy performance (OE3.2), favouring the rehabilitation of existing buildings, through concerted and coordinated action between the state and municipal supply, segmented by different target groups.

4. **Promoting knowledge and informed action (EE4). Action along these lines pursues four strategic objectives:**

Increase the capacity to identify households in a situation of energy poverty (OE4.1), by developing new statistics, developing knowledge on the problem of energy poverty, in particular on the relationship between energy poverty, income, comfort, health and social inclusion, for different socio-economic profiles, and diversifying support structures for identifying households in energy poverty.

Increasing energy literacy (OE4.2), targeting different audiences, from the general public to children and young people and people experiencing severe energy poverty and/or at risk of exclusion.

Stimulate research and innovation (OE4.3), promoting social and technological innovation, as well as innovation in financing, including new instruments based on civil society as well as in the energy, social security and national health system sectors.

Stimulate the training of professionals (OE4.4) needed to carry out interventions in rehabilitation, energy efficiency and renewable energy in housing, acting on the supply of professional training, both for specialisation and acquisition of new skills.

Among the 24 individual measures foreseen in the ELPEE, there are 8 measures that are most relevant for the development of the REVERTER renovation roadmaps, as fully aligned with our main goal (see section 7 for details).

Mention should also be made of the government's approval of Council of Ministers Resolution no. 8 -A/2021, of 3 February, of the Long-Term Strategy for the Renovation of Buildings (ELPRE), with the aim of responding to the need identified in PNEC 2030 to develop and implement a long-term strategy to promote the renovation of buildings, the main objective of which is to achieve a decarbonised and highly energy-efficient building stock, transforming existing buildings into near-zero emission buildings (NZEB).

ELPRE analyses the energy needs and thermal comfort of the building stock in Portugal and its potential impact in terms of co-benefits, which include reducing the country's energy bill and dependence, improved levels of comfort and indoor air quality and health benefits, greater labour productivity, combating energy poverty, extending the useful life of buildings and increasing their resilience. Among ELPRE's axes of action, there is a specific axe for combating energy poverty, which establishes policies and actions to reduce energy and other consumption costs and to support the

most vulnerable households in the energy renovation of their homes. The specific actions included in this line of action are presented in Table 1.

Table 1: Policies and actions envisaged in ELPRE to combat energy poverty (source: ELPEE).

Policies	Actions
Provision of funding and tax benefits for rehabilitation works	Publicising and promoting existing financial support for local entities that carry out programmes to support energy renovation programmes in social housing; Study the introduction of tax benefits and energy saving bonuses as part of the buildings' energy certification scheme; Propose the inclusion of a social criterion in the allocation of financial and tax benefits.
Increase comfort conditions	Supporting the most energy vulnerable populations or low-income families through, among other things, specific funding support programmes for the renovation of buildings, with a view to making investments in energy efficiency; Study the allocation of support for replacement/acquisition of space heating and DHW systems with efficient systems (e.g. solar thermal, heat pumps, surface geothermal), as well as the replacement/acquisition of more efficient taps, showers, flushing cisterns, from a water-energy nexus; Promote the integration of the most vulnerable populations or low-income families in renewable energy communities, combined with promoting the replacement of fossil-based equipment for electricity; Support measures for space heating and DHW systems through the online tool (European project HARP) to issue energy labels for heating equipment, visualising alternatives on the market and contact suppliers; Supporting measures relating to water use devices, which can be supported by national water certification systems of existing products at the national level[2], and at the European level, with the upcoming Unified Water Label, informing on the performance of water-using devices. Ensure the alignment of the long-term strategy for combating energy poverty with ELPRE, with the aim of obtaining a diagnosis and characterisation of the problem, developing monitoring indicators, monitoring strategies, and establishing objectives to fight against energy poverty in the medium and long term, at the national, regional and local level, and propose specific measures, including measures in the field of renovation of building stock, as well as forms of financing.

In addition to the public policy instruments on energy, there are also instruments from other areas of government action that must be understood in an integrated and articulated way, in the fight against energy poverty, in particular:

- The **National Strategy to Combat Poverty** 2021-2030 (RCM nº184/2021), which embodies a more comprehensive approach to combating poverty, the economic recovery of Portugal, the mitigation of social inequalities and a generalised improvement in the living conditions;
- The **Affordable Renting Programme** (DL nº 68/2019) which aims to promote a wide range of rental housing at prices compatible with household incomes;

[2] Associação Nacional para a Qualidade nas Instalações Prediais

- The public housing stock (DL nº 82/2020) aims to increase the supply of publicly-supported housing in order to respond to middle-income households who have difficulty accessing housing;
- 1º Direito (the 1st Right) - Programme to Support Access to Housing, which aims to support the promotion of housing solutions for people living in poor housing conditions, without the means to support the cost of an adequate house;
- The Rehabilitate to Rent Programme - Affordable Housing, which aims to finance renovation operations for buildings aged 30 years or more which, after renovation, should be allocated to the Affordable renting Programme;
- Financial Instrument for Urban Rehabilitation and Revitalisation 2020 (IFRRU 2020), which is a financial instrument that provides loans on more favourable terms than the market, for the comprehensive rehabilitation of buildings, activities, including the most appropriate integrated energy efficiency solutions for the rehabilitation.

Driven by the European Policies, and recognizing EP as a significant social, economic and public health problem, in the scope of LTRS and RRP and after a long period under public consultation, the Portuguese Government finally (November 2023) approved the resolution establishing the National Long-Term Strategy to Combat Energy Poverty 2023-2050. Its main goal is to eradicate energy poverty in Portugal by 2050, protecting vulnerable consumers and actively integrating them into the energy and climate transition, which is intended to be fair, democratic and cohesive. The final document does not diverge from the draft document and aims to reduce the percentage of Portuguese without money to heat their homes in winter by 7.4%, establishing a level of people living in energy poverty in 2030 of no more than 10 %. This is a very modest ambition, considering the moderate climate of Portugal and the EU average standing at a lower value already by now (9.3% in 2022). To achieve this end, the strategy is structured around four strategic lines of action:

- promoting the energy and environmental sustainability of housing;
- promoting universal access to essential energy services;
- promoting integrated territorial action;
- promoting knowledge and informed action.

In addition, the National Energy Poverty Observatory was also created, with the mission of monitoring the evolution of energy poverty at the national level, thus completing one of the milestones set out in the reprogramming of the Recovery and Resilience Plan.

Building renovation framework and practice in Portugal

There is no definition of deep renovation in Portugal, but the National Energy and Climate Plan and the Long-term Renovation Plans, together with the recently approved National Strategy for Energy Poverty, are important drivers to increase building renovation rates, thus creating a favourable framework for the diffusion of the REVERTER roadmaps. Local regulations at the Municipal level often limit the scope of renovation possibilities due to specific requirements for the façades, etc., (e.g. Municipal Masterplan and Municipal Urbanisation and Building Regulations) as well as there are too many formalities (licenses, etc. ...) to start the process. This implies a long process for each individual procedure. Time and bureaucracy are important barriers for renovations to be carried out.

In terms of regulations for renovations, Portugal is well advanced, yet the bureaucracy and complexity behind the processes postpone the household decision to enter into a renovation process by themselves.

Buildings decarbonisation is supported through a range of programmes and measures pushing for improved energy efficiency, higher electrification and the use of renewable energy. Under the National Buildings Energy Performance Certification System (SCE), all residential and commercial buildings must be audited to receive an energy certificate when they are built or deeply renovated and each time the building changes ownership or is leased. The SCE has contributed to better-insulated buildings, resulting in lower energy demand and emissions.

As of January 2019, all new buildings owned or occupied by a public entity need to satisfy nearly zero-energy buildings (NZEB) requirements. Starting in January 2021, all newly constructed or majorly renovated private buildings with an area greater than 1,000 square metres (m^2) need to satisfy NZEB requirements. Portugal's national building code requires the installation of solar thermal heating systems with a minimum size of 1.0 m^2 per building occupant (or other renewable energy systems providing similar energy savings). In February 2021, the government published the Portuguese Long-Term Renovation Strategy, which promotes building renovation through indicative objectives of renovations, primary energy savings and a reduction of hours of discomfort for 2030, 2040 and 2050. The strategy also defines measures to support the achievement of these objectives.

Portugal does not have a specific definition of nZEB for renovation, but the same requirements must be met to achieve a nZEB for the cases of new and existing buildings. Complying with nZEB requirements for the renovation of existing buildings is not mandatory, but it is encouraged. A deep renovation is related to measures being made in the building envelop. The renovation process essentially takes place in three main phases from the idea of renovation to an energy-efficient building.

The **First Phase** consists of obtaining information, evaluating and making a decision about the renovation of a building and is divided into 3 main stages:

1) Obtaining and evaluating information such as: Thermographic maps; Consultancy and counselling; Estimating preliminary renovation costs; and Financing options for the renovation.
2) Decision by the building's residents in favour of renovating the building;
3) Creation/Election of the Condominium with administrator and assembly.

The **Second Phase** consists of preparing the building documentation and is divided into 3 main stages:

1) Obtaining an energy certificate: a "roadmap" that provides consumers with information on the energy performance of buildings, which includes cost savings, improved thermal comfort and access to financing and tax benefits. It can indicate which works should be carried out and in what order to achieve maximum energy savings;
2) Technical opinion: The result of a technical inspection that can be carried out by a duly certified professional. During this process, all parts of the building are examined to determine their degree of deterioration and safety, resulting in an operational plan and the order in which the work should be carried out.

3) Documentation for the refurbishment operation: This phase requires an individual description of the building's refurbishment plan with a specific list of works to be carried out, based on the opinion of the technical inspection and the energy certificate.

The **third and final phase** consists of financing and renovating the building and is divided into five main stages:

1) Financing the renovation project: Once the opinion has been obtained, it is possible to go ahead with the renovation project, but first, it is necessary to take care of the sources of financing, own and/or request for auxiliary financing;
2) Selection of the builder: According to the requirements developed for the renovation of the building, construction companies can be selected. The construction companies draw up their detailed proposals for the renovation of the building so that the one with the most favourable conditions for the project is chosen;
3) Renovation of the building: The renovation of the building is carried out in accordance with the specifications, which contain information on the work to be carried out, the materials used and the timetable for the work. The person responsible for the work and the person responsible for monitoring the work control and monitoring the renovation work to ensure that it is carried out in accordance with the building project. If in doubt, residents should contact these specialists;
4) Transfer of the building: The contractor renovates the building in accordance with the contract. Once a month, summaries of the work completed are made and recorded in the works diary. A report is drawn up (including photographs) on the completed work phases. This report is signed by the construction manager, who is a person chosen by the residents and represents the interests of the building's residents. The construction manager checks that the materials and technologies agreed upon in the contract have been used and that they comply with the previous documentation (specifications). If deficiencies are detected in any of the renovation phases, the construction manager informs the contractor and makes sure they are eliminated. When all the work has been completed, the acceptance and handover document is signed, which confirms that the work has been completed in accordance with the requirements of the contract;
5) Applying for funding: this must be done before starting work. There are some government instruments in Portugal that support the energy renovation of buildings.

Ongoing national and local actions to mitigate energy poverty

According to the most recent Portuguese strategic view for 2030, the NECP recently identified energy efficiency as being crucial for the decarbonisation of society and as a response to the need for a competitive economy and a resilient, secure and self-sufficient energy system. In this context, Portugal commits to the principle of 'Energy Efficiency Priority' when deciding on investment projects in the energy sector, with a view to sustainability and cost-effectiveness. This logic has been reflected in the available financing mechanisms, for the domestic and services sector, through the Environmental Fund or the Recovery and Resilience Plan. The energy renovation of the national building stock and the decarbonisation of energy consumption, including through enhanced electrification, are key measures to meet national energy and climate objectives, as well as to meet other policy objectives, such as tackling energy poverty and supporting vulnerable consumers, in line with the aim of ensuring a just and cohesive transition. In the residential sector, the aim is to increase the thermal comfort of households (heating and cooling), focusing on passive insulation, sun

protection and ventilation solutions, and continuing with the trend towards electrification of the sector and the use of renewable energy sources. A continued focus on urban regeneration will provide an opportunity to incorporate energy and water efficiency improvements, the incorporation of low-carbon materials and renewable energy sources, contributing to the fight against energy poverty.

In relation to financing help for building renovations, the existing national support schemes to alleviate EP are not addressing deep renovation. Recently, the Climate Fund launched an incentive programme to support the replacement of old windows by efficient ones, in the residential sector, but the scheme was not designed to address energy poverty as there was a need to advance the payment. Vulnerable consumers are struggling to pay the bills and cannot afford to pay the upfront costs.

Nevertheless, there are some National Incentives and interesting instruments for lending funds for renovation works (IFRRU and 1º Direito), as well as specific financial incentives for low-income families, such as the energy efficiency vouchers, available since November 22, which can amount to 3900€ per household and there is also VAT reduction for energy renovations. Even though it is not possible to deeply renovate a dwelling, the eligible amount allows some improvements to be carried out. The central government has also been promoting the use of RES by low-income households, by creating the regulatory framework for the establishment of Renewable Energy Communities (REC). Transposition of new targets regarding energy savings (new EED recently approved with new yearly reduction targets), and the ongoing revision of the EPBD, setting more ambitious targets and requirements such as the MEPS for existing buildings, will ensure the ongoing efforts to improve the building stock, starting with the most energy inefficient buildings. At the local level, several municipalities already developed or are developing the Local Strategy for Housing and the SECAPs. There are other interesting National initiatives financed by the climate fund, aiming to promote actions at the local level, to improve the quality of life in the neighbours of the cities, which are inspiring and are also a lever for REVERTER activities.

1.3 Identification of the key stakeholders including the procedures for their engagement

The implementation of the envisaged building renovation roadmap requires the involvement of various bodies and authorities, which are illustrated in Figure 1. The mapping of the involved bodies and authorities pinpoints that the development of a governance mechanism, which will facilitate the communication and cooperation of the entities involved, is imperative.

The identified bodies and authorities represent different administrative and social levels with completely different priorities and aspirations. The cooperation of these stakeholders (Figure 1) is crucial in identifying the energy-poor households facilitating their participation in the planned policies and measures and collecting the necessary data to evaluate both the implemented policies and measures and the evolution of the energy poverty phenomenon at national, regional and local level.

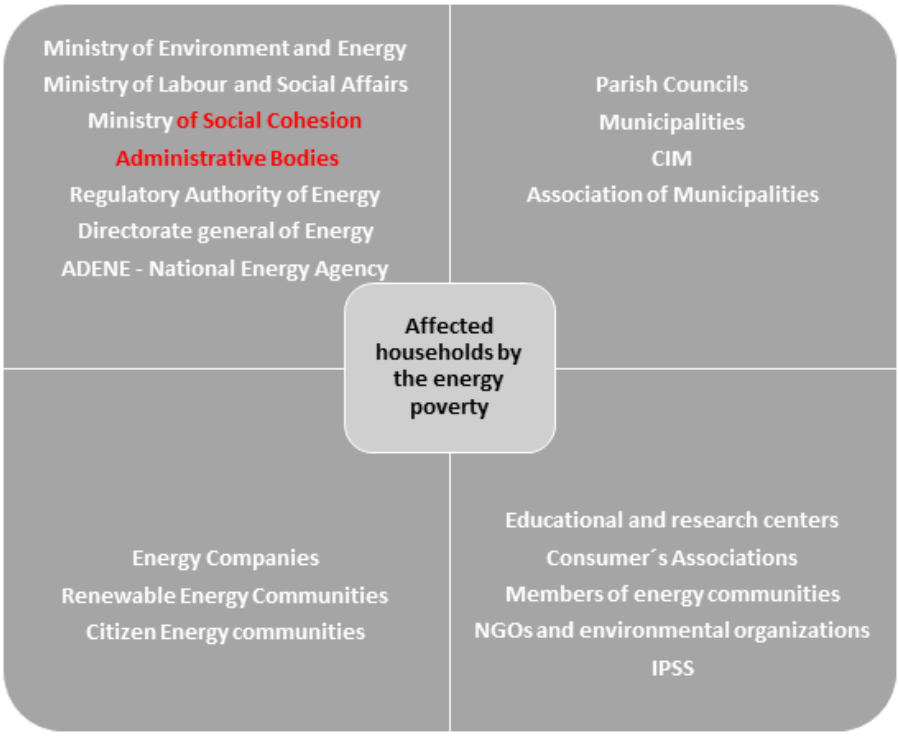


Figure 1. Overview of the involved stakeholders in the preparation of the building renovation roadmap.

In Portugal, the primary target groups are:

i. **Tenants** living in social houses, multifamily apartment buildings and houses. By empowering our target group with information and support, we are providing them with the ability to perform better and take part in the transition.

ii. **Energy Ambassadors and facilitators**, who help bridge the gap between the project and the households, raising their awareness about energy savings and engagement towards energy renovations

iii. **At the local level decision-makers**: partnerships with local authorities (social service department of the Municipality, parish councils, ...)

- **Local Social Support Entities**: important institutions that have the local identification of low-income families and give them social support locally. Their association with the project gives transparency and trustiness to the local implementation of the project actions and contributes to a better and quicker engagement (Santa Casa da Misericórdia and the Cáritas Diocesanas, Associação de moradores do bairro do Ingote, ..., for example). These organisations have a decades-long track record of working with socially disadvantaged people, in particular the elderly and the hard-to-reach energy users[3], and could also work as facilitators helping identify potential beneficiaries of the project's actions and establishing communication channels.

[3] Individuals who are physically difficult to reach, underserved, ethnic minority groups, or challenging to engage

- **Other local authorities** are the Central Region Coordination and Development Committee (CCDRC), responsible for setting up and managing the Central Regional Operational Programme; The CIM, the Regional Energy Agency AREAC for its presence near the citizens;
- Neighbourhood Associations and NGOs working with vulnerable consumers (e.g. Reabilita Coimbra, etc.)

iv. **At the National level,** policy makers, meaning the Portuguese Government, as they are the main decision-makers for overall policies in the country. In the Government, there are particular Ministries and Authorities to reach, whose decisions have a real impact on the way the buildings are built and retrofitted, or the funding mechanisms are designed particularly:

- Ministry of Housing that deals with housing problems particularly the construction of social housing to tackle the lack of affordable and equitable housing;
- Ministry of Territorial Cohesion that deals with equitable opportunities for all regions and manages the EU Funds for regional development;
- Ministry of Labour, Solidarity and Social Security, main responsible for social development within the country
- Ministry of Environment and Climate Action, for the responsibility to set up and manage the Climate Fund;
- Other Authorities to target are the Directorate General of Energy, the National Energy Agency (ADENE) and the Parliamentary Groups of the parties because these are easier to reach.

Therefore, in relation to the **secondary target groups to be involved** in Portugal:

v. **Companies** and **energy** and **housing cooperatives** that can implement renovation measures and/or integration of renewables in the renovation of the houses as well as the creation of Renewable Energy Communities in rural areas (Coopérnico, CleanWatts, ITeCons,...);

vi. The support of existing financing mechanisms, e.g., Fundo Ambiental (Environmental Protection and Energy Efficiency Fund), for co-financing measures defined in national energy and climate plans. Third-party investors will also be contacted to deliver their support at the local level. This is the case of the Renewable Energy Communities that could require third-party investors and may require the involvement of local authorities.

Different means will be utilised in order to conduct the foreseen consultation activities, such as indicatively:

- Organization of tertulias and bilateral meetings with the participation of the key players to discuss the main provisions of the building renovation roadmap;
- Launch a stakeholders consultation to collect feedback;
- Organization of a Round Table with the participation of the identified stakeholders to discuss the received comments during the consultation procedure and challenge the municipality to sign a Memorandum of Intent for the municipality.

2 Analysis of the current levels of energy poverty in the pilot area

According to recent statistics by Eurostat, in 2022, the country recorded the fourth highest rate in the European Union (17.5 %) of people who were unable to heat their homes properly, with the European Union average standing at 9.3% (Figure 2). Focusing on the Pilot area and looking at the indicators being used by official statistics, the percentage of the population living in a dwelling with leaks, damp or rot is higher than the national average (almost by 2%). The percentage of the population not able to keep their home adequately warm also exceeds the national percentage (almost by 3%). A better condition is observed in the case of the indicator Share of the population having arrears on utility bills, at least for the recent years.

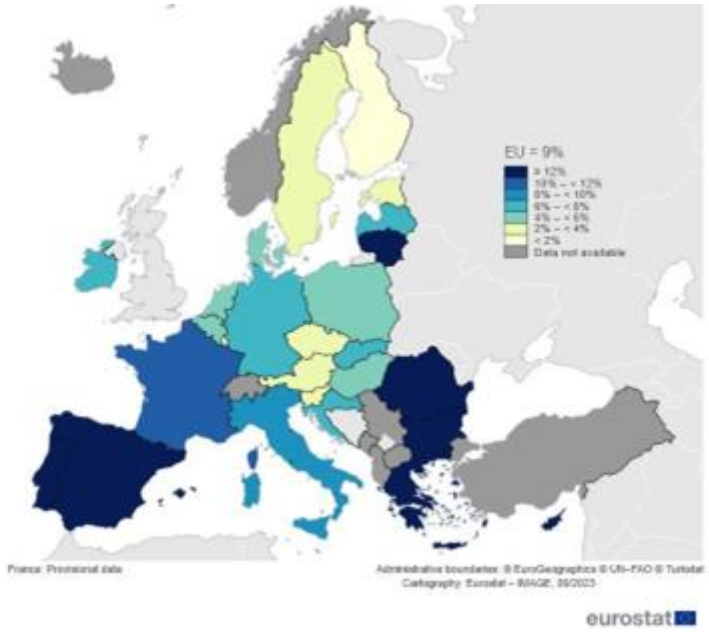


Figure 2: Inability to keep home adequately warm, 2022 (source: Eurostat).

Since, until recently, there was no consensus nor an official definition of EP, actions being carried out were aimed to characterize the circumstances that contribute to the energy poverty of vulnerable consumers, as well as their impacts, to identify intervention opportunities that can combat energy poverty. In the absence of an official Energy Poverty definition, EP is understood as the inability to maintain housing with an adequate level of essential energy services, due to a combination of low income, low energy performance of dwellings and high energy costs, which can be translated by the following indicators:

- arrears on utility bills;
- low absolute energy expenditure;
- high share of energy expenditure in income;
- inability to keep home adequately warm.

The analysis of the current situation of energy poverty and vulnerability of the population in the pilot of Coimbra was based only on data from Eurostat's EU SILC survey, using the microdata provided by Portugal (at the household level) for the years 2017-2021. Nevertheless, for 2017 there was no separation into NUTS2 regions. For this reason, the final dataset included observations for

the years 2018-2021. From this dataset, the observations selected were those that referred to region PT16 (variable DB040) and degree of urbanization 2 (variable DB100 - towns and suburbs/intermediate area). This subset of the data includes other areas than Coimbra but with similar characteristics.

According to Figure 3, the percentage of the population living in a dwelling with leaks, damp or rot in the Portuguese pilot area is higher than the national average (almost by 2%). It is worth noting that leakages-damp problems within the pilot area deteriorated in 2020, marking an increase of up to 23.6%, while also exceeding national rates for the first time.

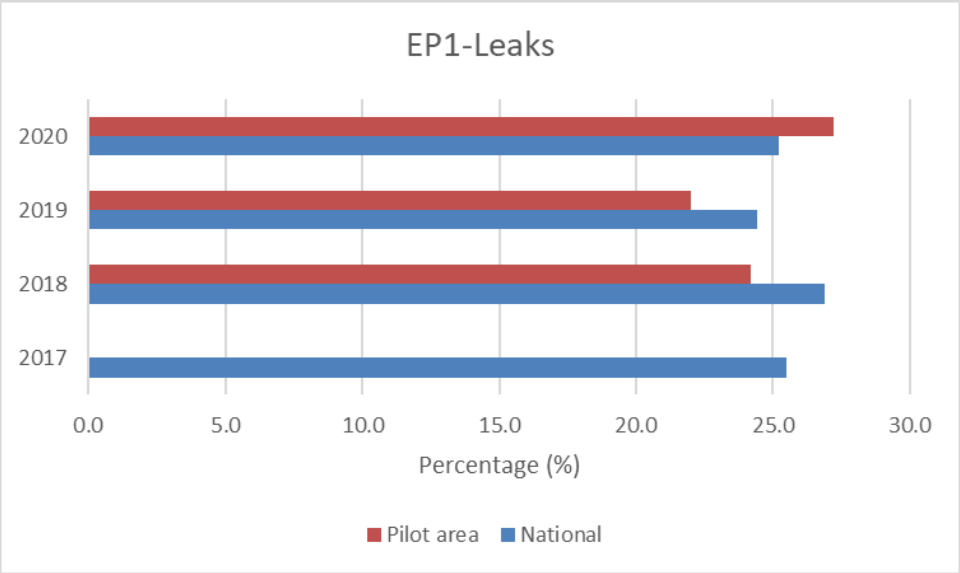


Figure 3. Share of the total population living in a dwelling with leaks.

The percentage of the population not being able to keep their home adequately warm also exceeds the national percentage (almost by 3%) in the pilot area, with the difference between the two rates increasing in 2021 as compared to the last two years (Figure 4). A better condition is observed in the case of the EP3 indicator (Figure 5) as fewer households seem to have arrears on their energy bills in the pilot area compared to the national level, in 2021. Still, the picture is worse compared to the previous three years, as all rates (both at the pilot-area level and at national level) were significantly lower.

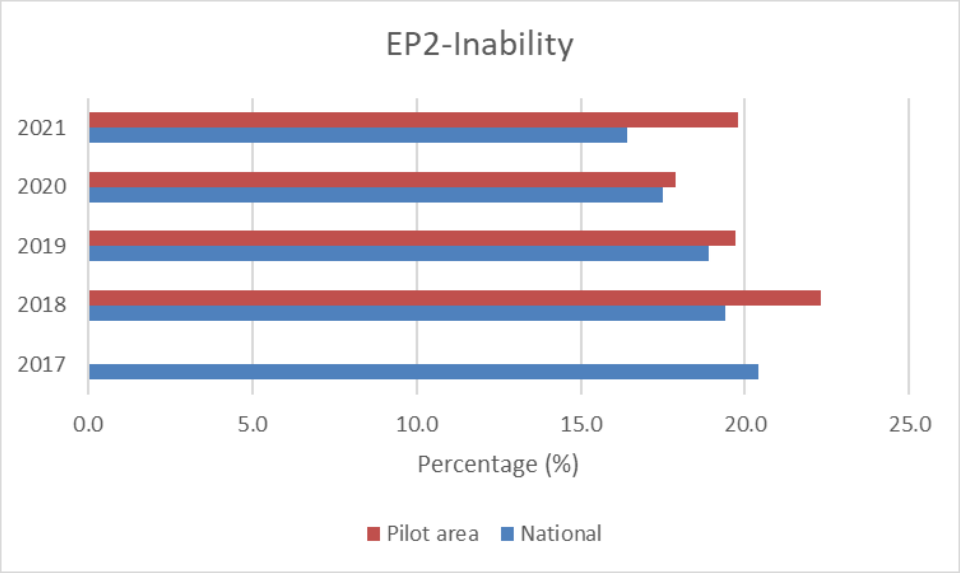


Figure 4. Share of the population not able to keep their home adequately warm.

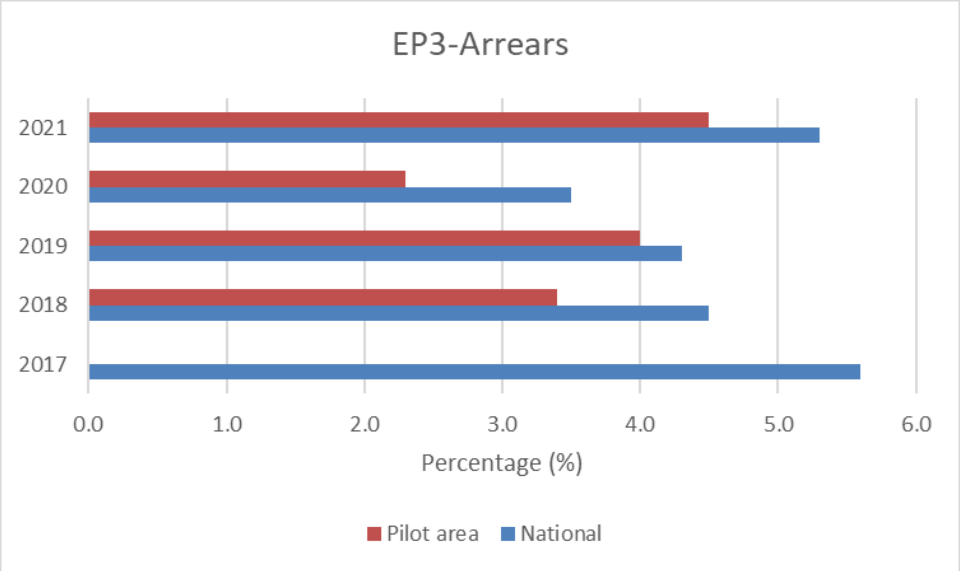


Figure 5. Share of the population having arrears on utility bills.

As in the other pilot areas, indicators EP4 to EP12 were examined only at the level of the pilot area. Indicatively, the percentage of the population having arrears on utility bills only once is low, i.e., 1% in 2021 and even lower than the previous years (0.1% up to 0.8%) Figure 6. The corresponding percentage of households with arrears on utility bills twice or more is greater, i.e., 3.5% in 2021 and without significant fluctuations over the years (on the order of 2-3%) (Figure 7).

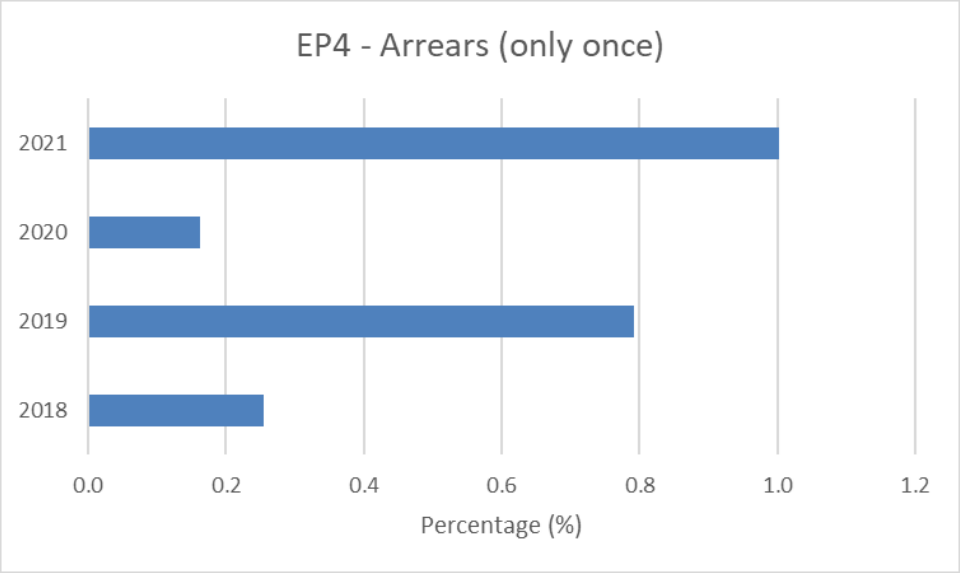


Figure 6. Share of the population having arrears on utility bills only once in the past 12 months.

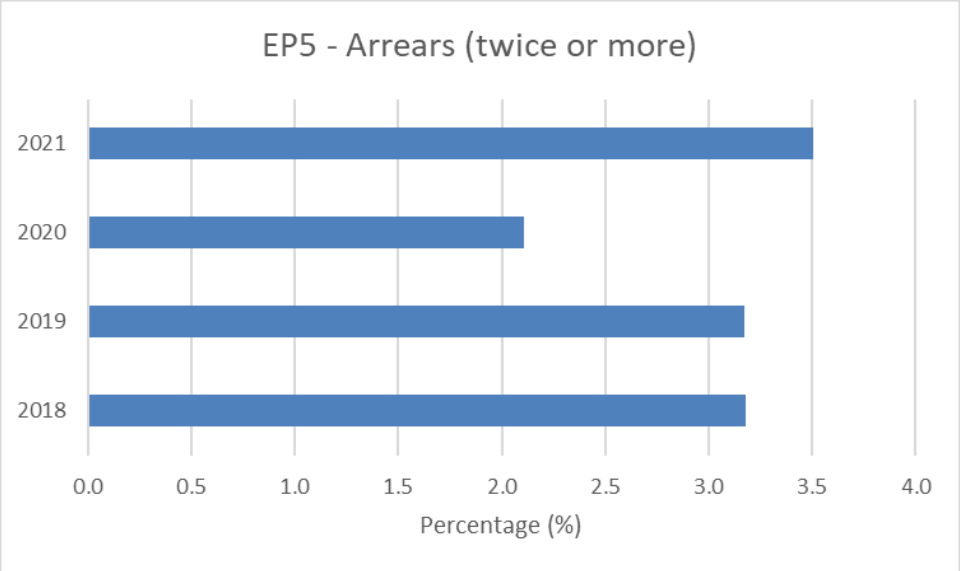


Figure 7. Share of the population having arrears on utility bills twice or more in the past 12 months.

Figure 8, Figure 9 and Figure 10 illustrate the results of the Weighted Composite Indices (WCI). The energy poverty problem seems to be rather stable over the years according to the three indices. For example, the percentage of the population without EP issues has remained in the order of 60% since 2018, while that with severe EP issues (i.e., WCI1 is equal to 1) has been reduced by 0.3 percentage points since 2018 (Figure 8). Similar conclusions are reached for WCI2 and WCI3, as shown in Figure 9 and Figure 10, respectively.

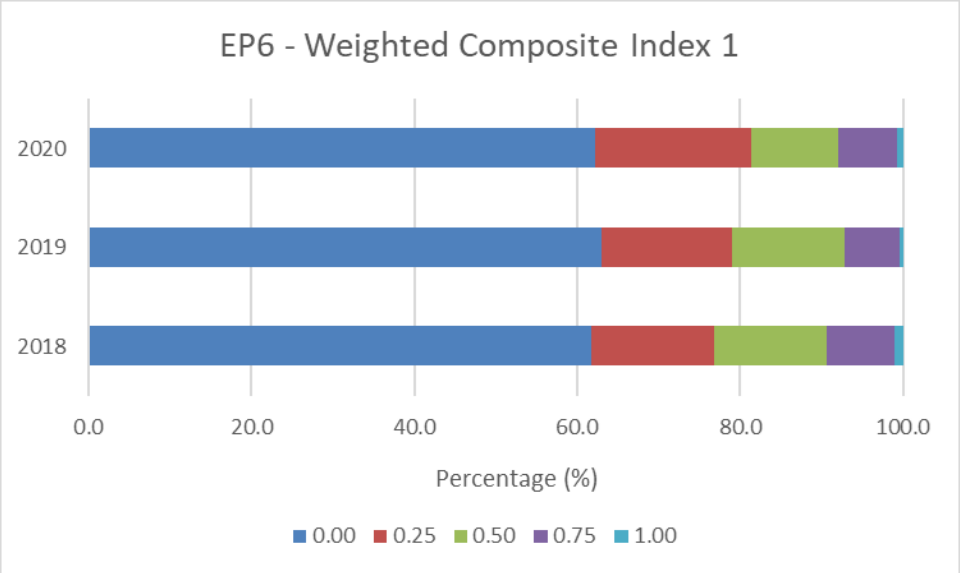


Figure 8. Share of the population at EP according to WCI1.

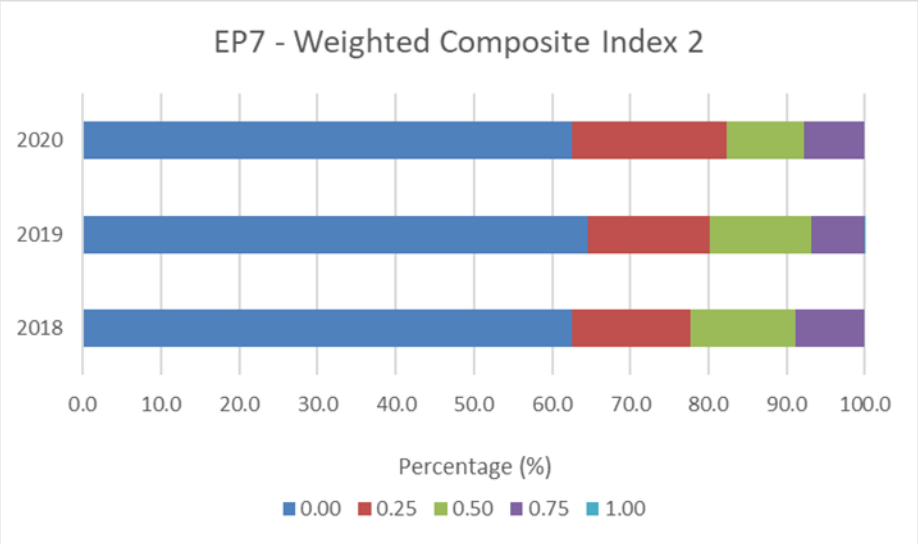


Figure 9. Share of the population at EP according to WCI2.

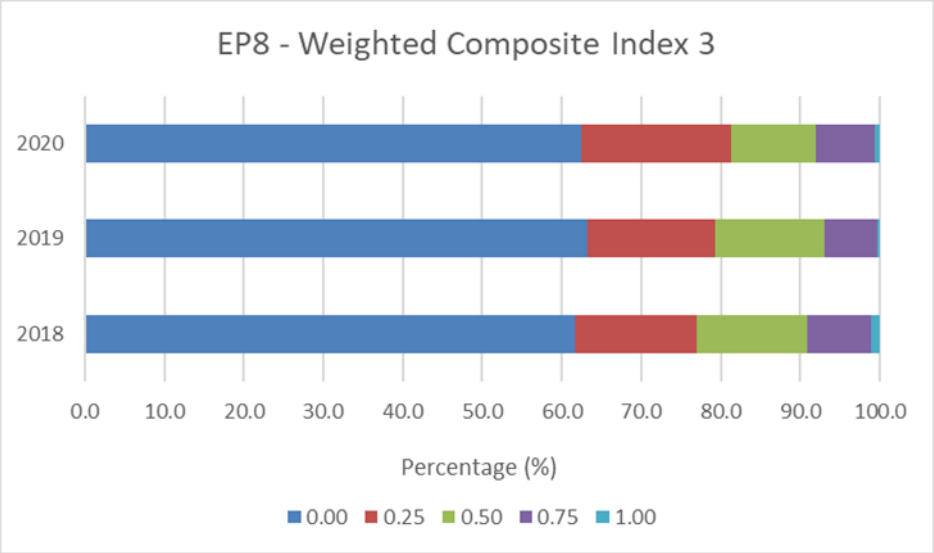


Figure 10. Share of the population at EP according to WCI3.

The Simple Composite Indices (SCI) also reflect the rather stable condition of the energy poverty problem. In all SCIs, the classes have retained similar rates since 2018. For example, the EP rate for households not experiencing EP issues (class 0) has remained on the order of 60% and the corresponding rate for those experiencing the most important EP problems (classes 2 and 3) has remained on the order of 10% since 2018 (Figure 11, Figure 12 and Figure 13).

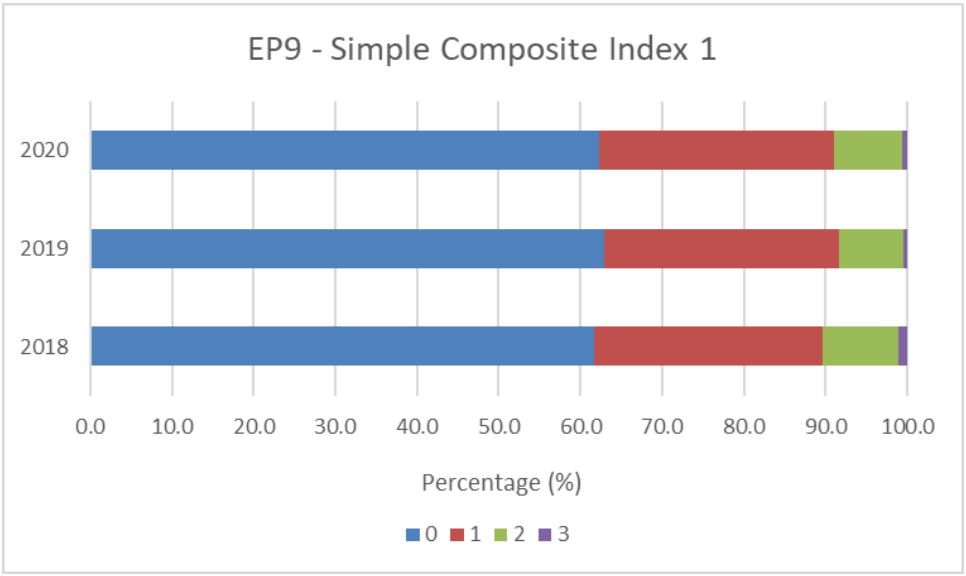


Figure 11. Share of the population at EP according to SCI1.

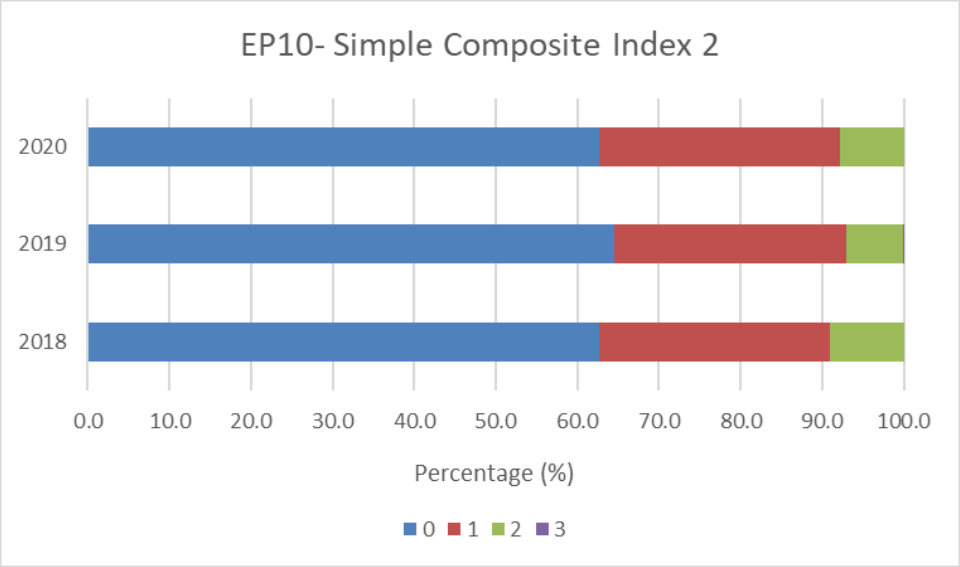


Figure 12. Share of the population at EP according to SCI2.

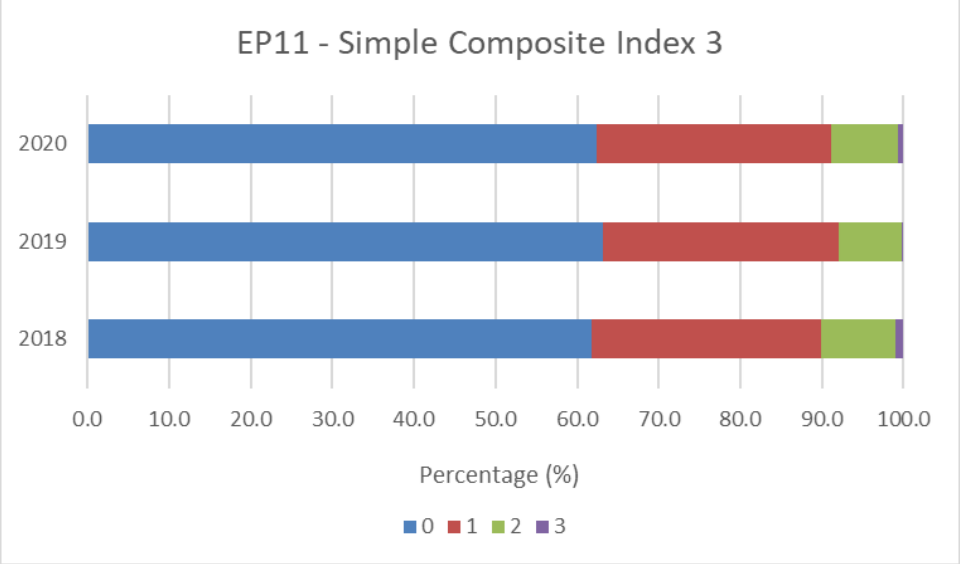


Figure 13. Share of the population at EP according to SCI3.

The percentage of the population facing any type of EP in the pilot area, i.e., inability to keep their house adequately warm, arrears on utility bills, or leaks/damp walls, shows a decreasing trend, according to (Figure 14). It is noteworthy that this indicator shows higher rates of energy poverty, as it combines all individual energy poverty indicators.

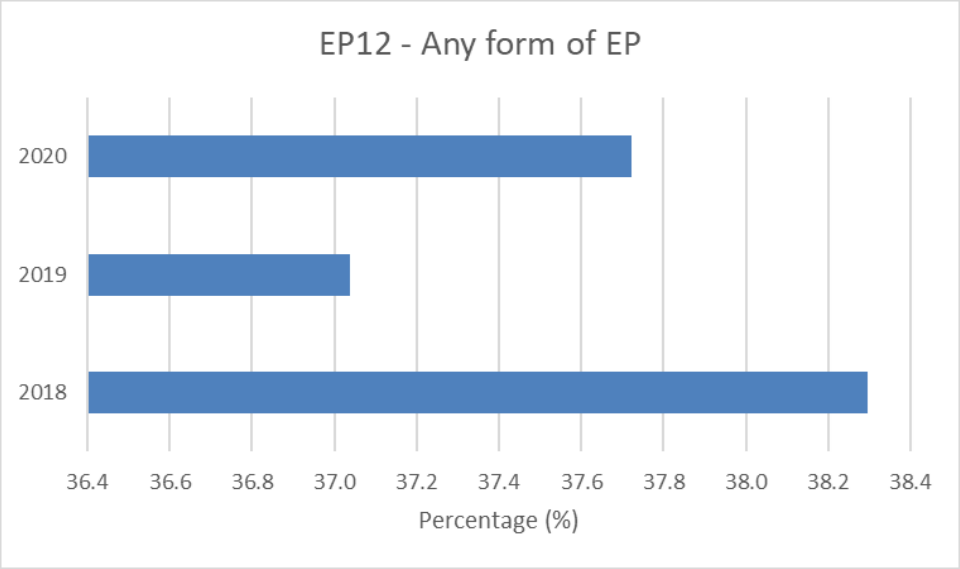


Figure 14. Share of the population at EP according to EP12.

Below, the relationship between EP vulnerability and certain housing features and living conditions is explored. As shown in Figure 15, households living in semi-detached houses face the highest problems with leaks and damp walls. They are also less prone to arrears and more capable of keeping their houses adequately warm. Households living in apartments (small buildings, followed by large buildings) present lower EP issues, on average, than the average rates.

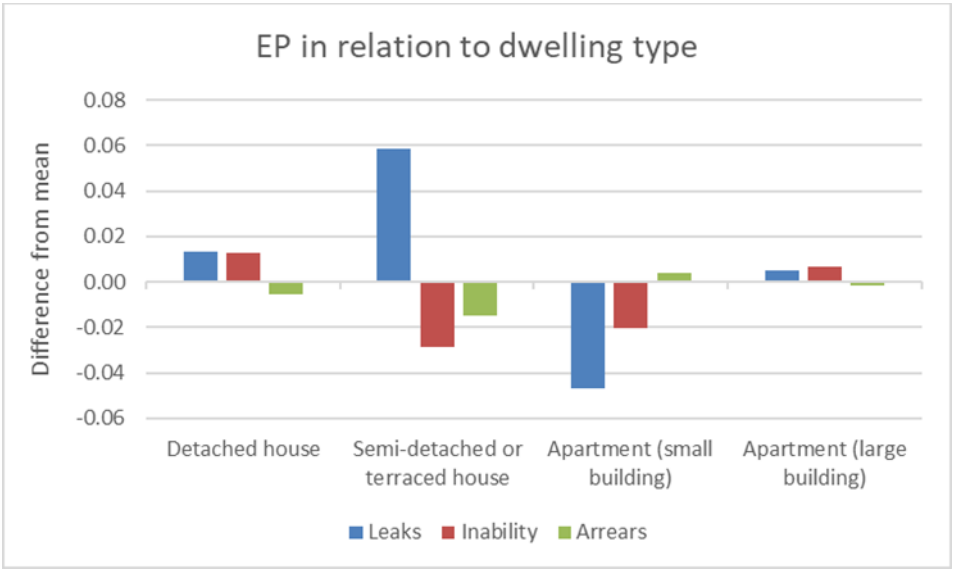


Figure 15. Leaks, inability to keep the house warm and arrears on utility bills in relation to dwelling type

The dwelling size is also related to the three basic EP indicators, as shown in (Figure 16). Households living in one-room houses present the highest problems in terms of leaks/damp walls compared to the average, while they are less prone to the other two indicators, on average. Households living in houses with four or more rooms have the lowest EP rates, probably due to the income of these households.

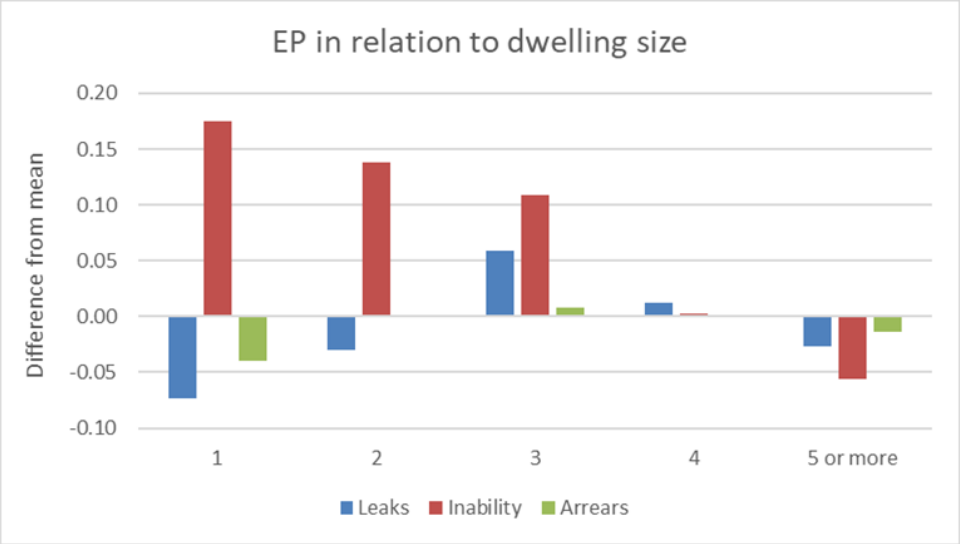


Figure 16*. Leaks, inability to keep the house warm and arrears on utility bills in relation to dwelling size.*

Regarding tenure status (Figure 17), the most vulnerable groups to EP are tenants who pay rent (either at the market or at a reduced rate) and households living in free accommodation. It should be noted though that tenants who pay rent at a reduced rate are the most vulnerable ones in terms of keeping their home adequately warm.

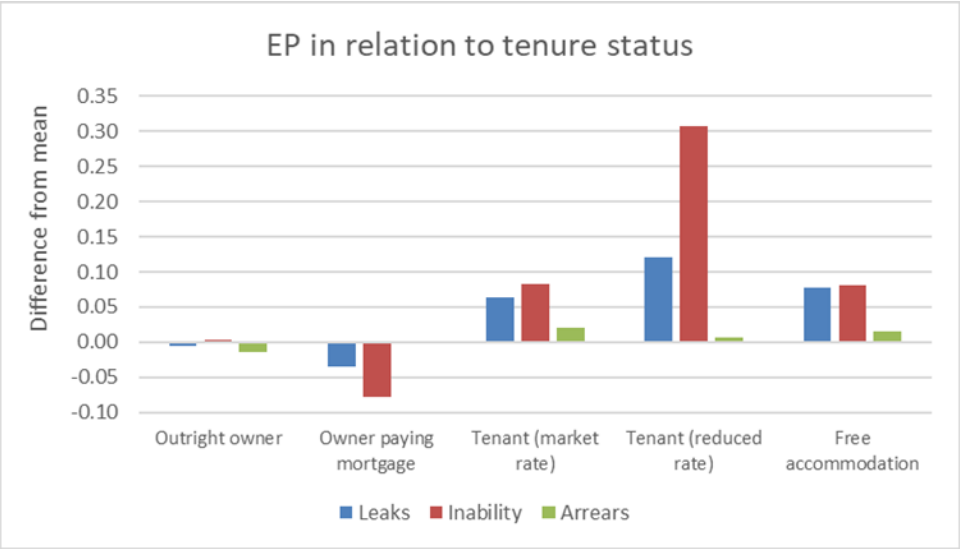


Figure 17. Leaks, inability to keep the house warm and arrears on utility bills in relation to tenure status

Figure 18 shows that households having trouble and great difficulty in making ends meet face also higher EP issues, with differences in EP rates of up to 25% in comparison with average rates. On the other hand, households that can easily make ends meet present quite lower EP rates, of up to 15% versus average rates.

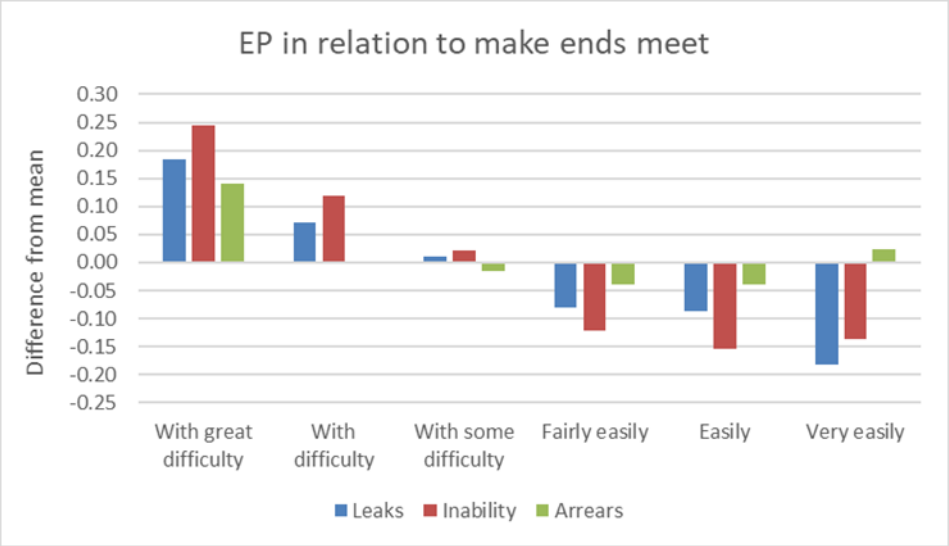


Figure 18: Leaks, inability to keep house warm and arrears on utility bills in relation to the level of difficulty in making ends meet.

As regards complementary EP indicators and certain housing features examined, it is shown that households living in small buildings are less prone to EP problems compared to the average rates (Figure 19), while those living in two and three-room houses are more energy-vulnerable (Figure 20). Tenants and those living at free accommodation status face higher EP issues (Figure 21), as also happens with households that face difficulty in making ends meet (Figure 22).

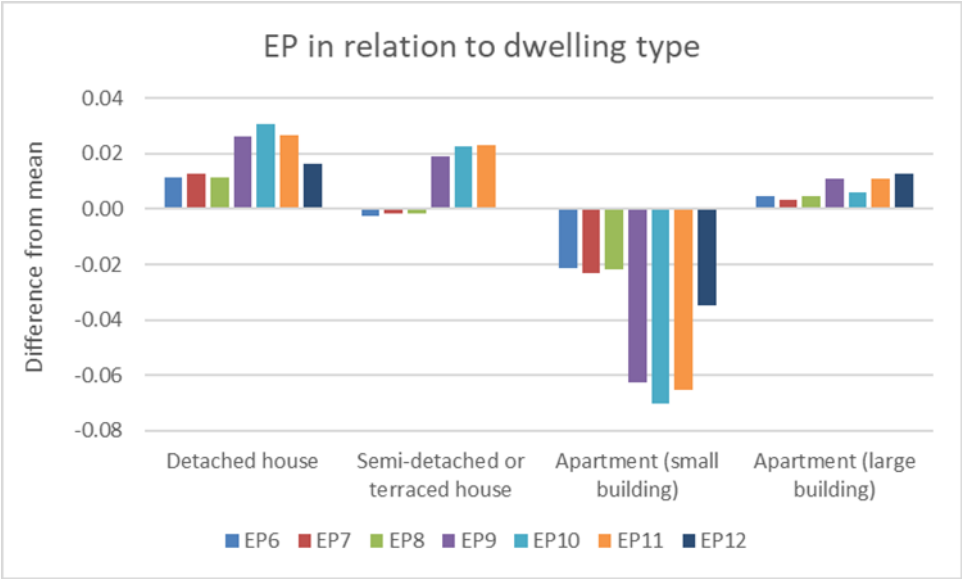


Figure 19. Complementary EP indicators in relation to dwelling type.

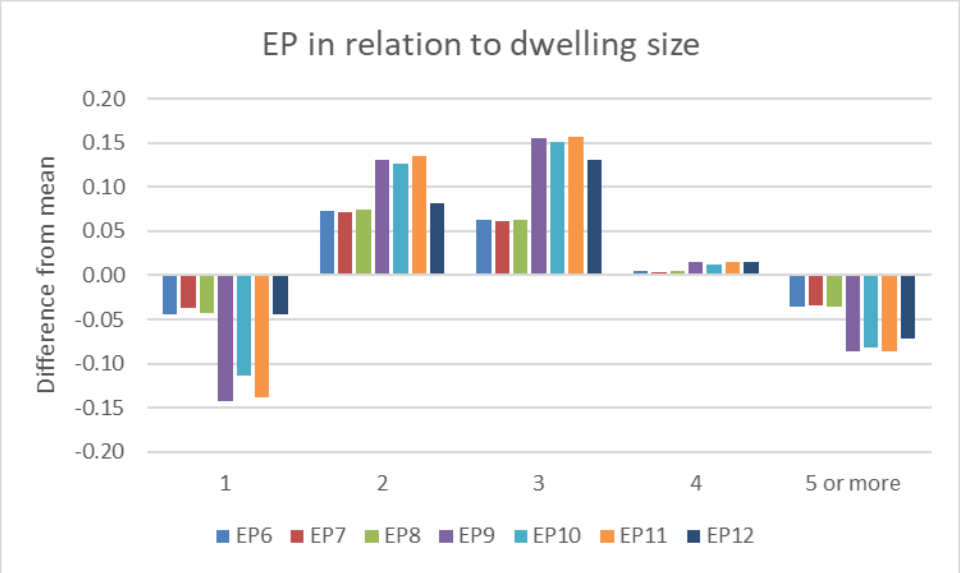


Figure 20. Complementary EP indicators in relation to dwelling size.

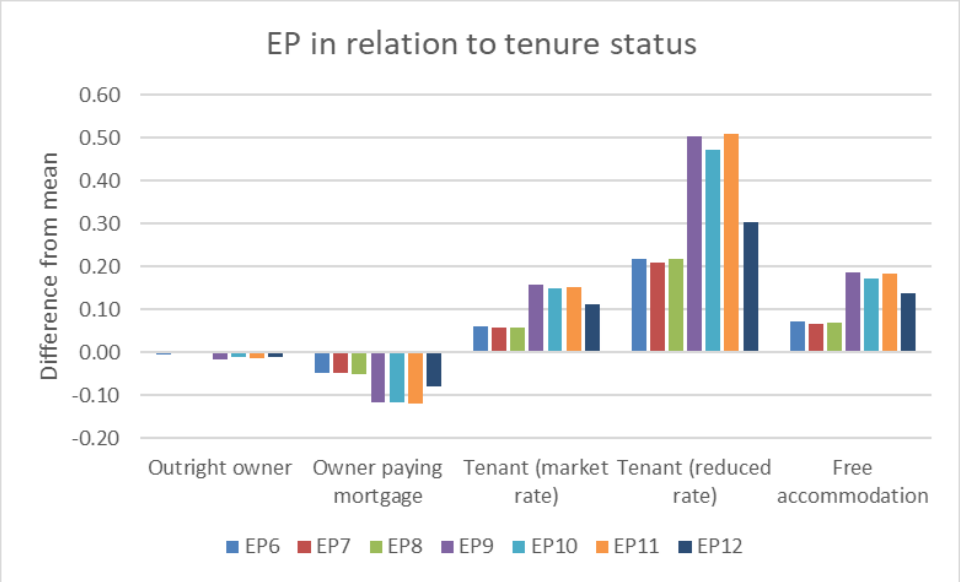


Figure 21. Complementary EP indicators in relation to tenure status.

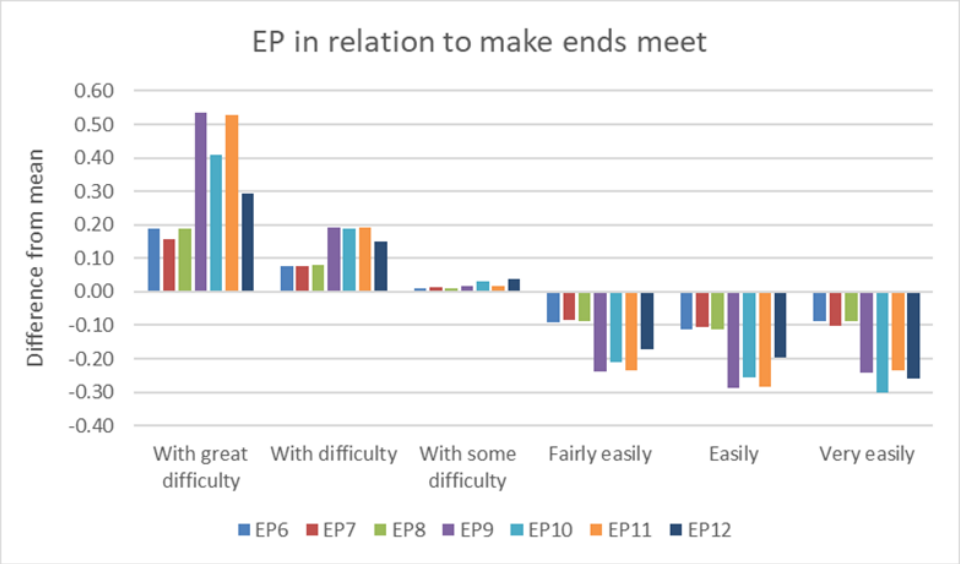


Figure 22. Complementary EP indicators in relation to the level of difficulty in making ends meet.

3 Analysis of the conditions in the Coimbra region

The Intermunicipal Community of Coimbra Region is an administrative division in Portugal. It was created in October 2013, replacing the previously existing Greater Metropolitan Area of Coimbra. Since January 2015, the Coimbra Region has also been a NUTS3 subregion of the Centro Region, which covers the same area as the intermunicipal community. The main city and seat of the inter-municipal community is Coimbra. The metropolitan area of Coimbra has a population of around 435,000 inhabitants, distributed over an area of 4 335.57km². **Error! Reference source not found.** p resents the geographical location of the selected Pilot Region.

NUTS II

NUTS III

The Coimbra Region is a statistical sub-region of level III (NUTS III), part of the Centre Region.

Figure 23. Location of the Coimbra pilot.

Located at an elevation of 40.19 meters above sea level, Coimbra, like most of Portugal, has a warm Mediterranean climate according to the Köppen climate classification: Hot-summer Mediterranean climate (CSa) and Warm-summer Mediterranean climate (CSb).

The city's yearly temperature is 16.78ºC and it is -0.03% lower than Portugal's averages. Coimbra typically receives about 92.11 millimetres of precipitation and has 105.45 rainy days (28.89% of the time) annually. The main geographical and weather data is the following:

- Longitude - 8.4102573
- Latitude - 40.2033145
- Attitude/Elevation - 40.19m
- Average annual high temperature - 20.99ºC
- Average annual low temperature - 9.97ºC
- Average annual precipitation - 92.11mm
- Warmest month - August (average temperature 29.64ºC)
- Coldest Month - January (average temperature 5.39ºC)

- Wettest Month - January (143.37mm)
- Driest Month - July (8.44mm)
- Average days of heating per year: Heating Degree Days in Coimbra Region – 1136,5 (2022)
- Average days of cooling per year: Cooling Degree Days in Coimbra Region: 114.4 (2022)

The climate of the Area is mild. As shown in Table 2, the average annual temperature is 17°C, the total annual precipitation is roughly 92.11 mm, and the average humidity is 74.1%.

Table 2. Coimbra climate data (1991-2020). Source: (https://pt.weatherspark.com/y/32332/Clima-caracter%C3%ADstico-em-Coimbra-Portugal-durante-o-ano).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average temp. °C	9	9	12	13	16	19	21	21	20	16	12	9	17
Average max °C	14	15	17	19	21	25	28	28	26	22	17	14	21
Average min °C	5	5	7	9	11	14	15	15	14	11	7	5	10
Rainfall mm	96.1	75.6	55.4	68.0	52.6	21.8	6.9	10.9	41.5	95.6	107.2	108.2	92.11
Humidity %	83.5	80.2	77.6	76.3	71.2	70.2.	67.4	64.9	65.3	70.9	81.5	80.4	74.1

The warm season lasts for 3 months, from 21 June to 20 September, with an average daily maximum temperature above 25 °C. The hottest months of the year in Coimbra are July and August, with a maximum of 28 °C and a minimum of 15 °C, on average (Figure 24). The cool season lasts for 3.7 months, from 17 November to 6 March, with an average daily maximum temperature below 17 °C. The coldest month of the year in Coimbra is January, with a minimum of 5 °C and a maximum of 14 °C on average.

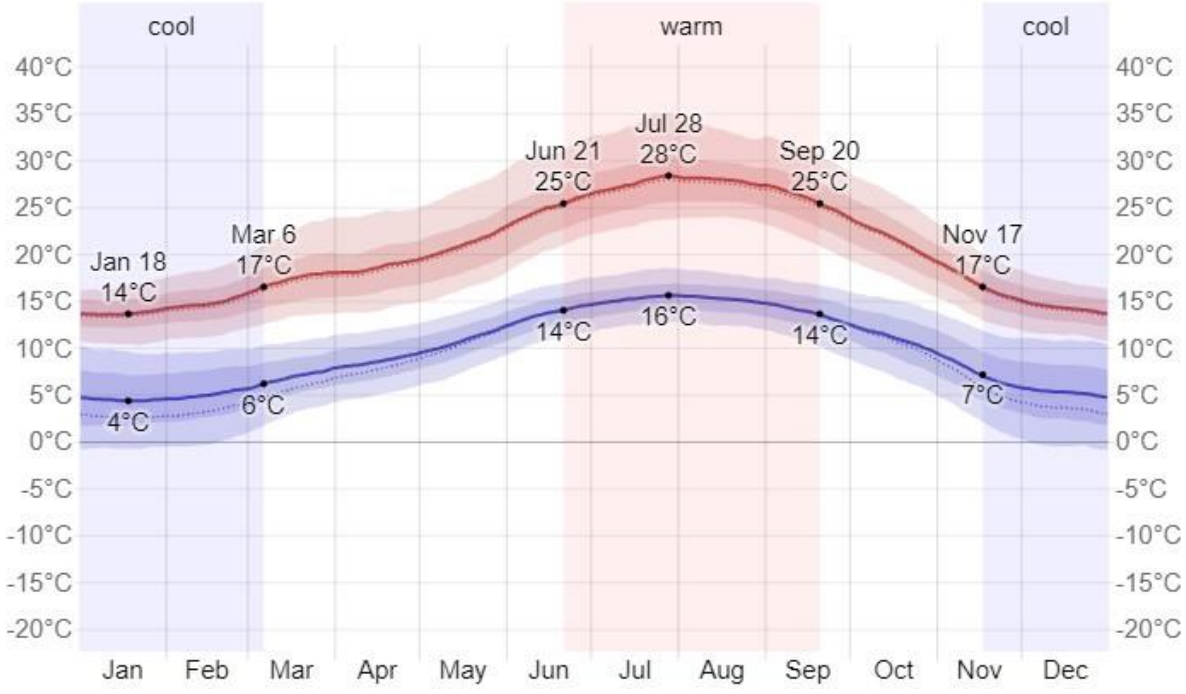


Figure 24: Average High and Low Temperature in Coimbra.

Table 3 and Table 4 present the average HDD and CDD per month for the study area for the period (2017-2022).

Table 3. HDD for the Portuguese pilot – monthly data (2017-2022 averages).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Coimbra	246.6	164.9	149.7	84.6	23.1	5.9	0.	0.	1.1	21.8	122.9	179.	999.6

Source: (Eurostat, 2023a)

Table 4. CDD for the Coimbra pilot – monthly data (2017-2022 averages).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Coimbra	0.	0.	0.	0.	5.9	14.4	35.3	34.4	18.1	2.9	0.	0.	110.9

Source: (Eurostat, 2023a)

The Coimbra Municipality, located in the Portugal Centre Region, has around 135,000 inhabitants. Its population is considerably aged (Figure 23), with an ageing index of 203.9 against the Portuguese average of 157.4 and the EU27 average of 132.3. In 2018, the Gini Coefficient in the region was 4.7.

Being mostly a city of the Services sector, with the main activities being related to health sector services, including hospitals, schools, and Universities, the Coimbra population, on average, has a good level of education and reasonable purchase power, when compared to other cities or rural areas. Nevertheless, when focusing on the neighbouring areas, and on the elderly living in social houses and in the downtown, where the housing stock is very old and inefficient, energy poverty in Coimbra is a major social issue.

The pilot will be focused on the most vulnerable households of the Municipality of Coimbra, who live in social houses under the management of the Municipality, in a very open and quiet suburban area, not far from the city centre. The target audience of REVERTER Pilot includes a population of about 150 citizens, who live in the poorest neighbourhood of the city; inhabitants facing the higher risk of poverty, mainly single parents, especially women, unemployed, ethnic minorities, and families with more than 3 children.

With a population of over 100 thousand (**Error! Reference source not found.**), the Coimbra Urban A rea is the largest urban conglomeration in the pilot region.

Table 5. Centre region and Coimbra permanent population – total and by gender (2021 Census).

Area	Permanent population	Men	Women	Men (%)	Women (%)
Coimbra Intermunicipality	436929				
Coimbra Municipality	140816	65451	75365	46.5	53.5
Coimbra Urban	84462	38800	45662	45.9	54.1

Source: (National Statistical Authority, CENSUS 2021)

In the pilot area, Coimbra city, about 46% are men and 54% are women. As mentioned before, the population of the pilot area is ageing, as shown in Figure 25.

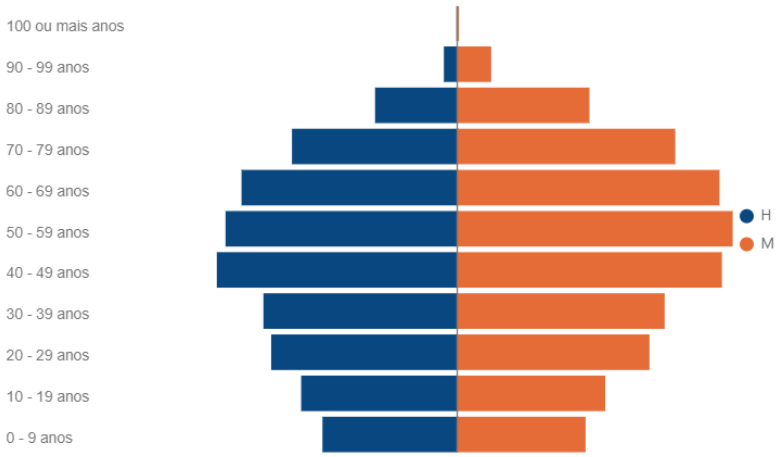


Figure 25: Permanent population by gender and age groups in the Coimbra Municipality (Source: CENSUS 2021).

In line with this fact, when comparing the CENSUS of 2011 and 2021, the share of one-person and two-person households has increased while three-person and more households have decreased. (PT CENSUS 2021).

The Gross Domestic Product (GDP) of the Coimbra Area was 7856 ~million € in 2020. The GDP per capita was more than 18,100 € (Table 6) or 60% of the EU27 average in the same year (Table 7), and the unemployment rate stood at 6.3% (national unemployment rate: 8.1%).

Table 6. GDP per capita at current market prices in Coimbra.

	2017	2018	2019	2020
Coimbra	17 200	18 300	19 000	18 100

Source: (Eurostat, 2023b)

Table 7. GDP per capita in Coimbra in percentage of EU27.

	2017	2018	2019	2020
Coimbra	59	61	61	60

Source: (Eurostat, 2023b)

4 Analysis of the building stock

4.1 Overview of the building stock for the targeted building types

Residential buildings represent the vast majority of the building stock in Portugal, with 77% of the buildings (Monzón-Chavarrías et al., 2021). Most of the buildings were built before 1980 (53.5%), i.e., before the first thermal building code was enacted in 1990. Therefore, these buildings do not have any thermal insulation. The decades 1961–1980 are typically considered as a period with buildings with a poor energy performance. For example, some experts studied the constructive solutions and energy performance of Portuguese buildings and argue that buildings erected during the ’60s, ’70s and ’80s are the ones with the highest energy-saving potential (Sousa et al., 2013). Other experts studied the energy performance certificates of residential buildings in Portugal and found that buildings erected before 1980 have higher levels of nominal heating energy needs (Magalhães & Leal, 2014). Additionally, the performance of the buildings in the inner part of the centre region is lower than in the more coastal area.

The building characteristics of the Coimbra region are influenced by its historical and cultural heritage, as well as its geographical and climatic conditions. Coimbra has a variety of architectural styles, ranging from Romanesque, Gothic, Renaissance, and Baroque, to Modernist. The traditional buildings in Coimbra are mostly made of stone, brick, and timber, with tiled roofs and plastered walls. In the old city, the buildings are usually arranged along narrow streets and alleys, forming dense urban blocks and are, in general, in bad condition. Some of the common building features are balconies, arcades, courtyards, and decorative elements such as azulejos (painted ceramic tiles), stucco, and wrought iron. The city has grown in the decades 60´s-90´s with a boom of new constructions, mainly buildings with more than 4 floors and new districts have been set in the city.

The quality of residential buildings in the Coimbra region is affected by several factors, such as the design, materials, construction, maintenance, and performance of the buildings. The quality can be measured by different criteria, such as structural safety, durability, functionality, comfort, aesthetics, energy efficiency, and environmental impact. According to a previous study, the majority of the traditional buildings in Coimbra have a high seismic vulnerability due to their poor structural condition and lack of adequate seismic capacity (Vicente et al., 2006). The study also found that the main causes of defects in the construction stage of residential buildings are related to the construction materials, inspections, equipment, management, and human errors. Therefore, it is recommended to adopt proper quality management practices and standards for the design, construction and rehabilitation of residential buildings in the Coimbra region.

The decades with the highest percentage of buildings constructed in Portugal were 1961–1980 (~30%) and 1981-1990 (~16%) [6]. The period 1961–1980 is included among the decades with the highest building construction growth. Additionally, this is considered the period when buildings had poorer energy performance. For these reasons, the REVERTER residential reference building in the national building stock, our baseline, was chosen to represent the characteristics of the social housing buildings of this period, in the centre region. Most of the multi-family buildings built between 1971 and 1980 in Portugal have 2 floors (33.7%) or 3 floors (19.4%), and the dwellings have a useful floor area of 70–99 m^2 (19.9%). Windows occupy 17–23% of the façades (Monzón-Chavarrías et al., 2021).

Regarding the type of construction, the majority of the Portuguese multi-family buildings built between 1971 and 1980 have reinforced concrete structures (54.15%), rendered and painted façades (88%), and pitched roofs with ceramic tiles (93.4%)[4]. The construction data of the Portuguese buildings are obtained from an official report on the thermal performance of buildings and the application of the Portuguese building thermal regulation [LNEC] and contrasted with other sources (Brandão de Vasconcelos et al., 2015; Palma et al., 2019). According to National Statistics in Portugal[5], electricity is the main energy source for heating, followed by gas, LPG (butane) and wood biomass. The main energy source for heating DHW is gas, followed by LPG (butane). Space cooling is provided solely by electricity.

Since the identification of the cost-optimal levels of minimum energy performance requirements cannot be calculated for every individual building, the EPBD requires all MSs to characterize first the building stock and then establish the Reference Buildings (RBs) that represent the stock. To characterize the reference building, the choice was to select a real building representing the most typical building in a specific category (building function type) for the Centre region (building location) and built before the Thermal building Code (construction period) (Brandão de Vasconcelos et al., 2015). This methodology of selecting a building that already exists requires a large amount of well-characterized information about the building, as well as of the building stock, but does not require supplementary information (like statistical analysis, etc.) (Brandão de Vasconcelos et al., 2015). Since the Coimbra Pilot focuses on Social Housing owned by the Municipality, the risk of having characteristics that are not representative of buildings in the same sample is very low.

As mentioned, the Coimbra Pilot will focus on developing two roadmaps (for MFBs and SFHs) targeted to consumers who are particularly vulnerable concerning the thermal comfort level in their homes. Solutions will not focus only on the building envelope and energy-efficient appliances but also on the urgent need to switch fossil fuel-based heating and cooking systems using gas to electricity by promoting solar thermal and roof photovoltaics (PV). Although with limitations regarding indicators and hard data, it is well known that the region has an at-risk-of-poverty rate of 17.3%. At-risk or EP-vulnerable households have been signalled by the Municipality services working in the field. However, due to the shortage of public budgets and other priorities (e.g., investing in public infrastructures or services, security, etc., which are more visible to citizens), programs dedicated to building renovations are scarce and actions to tackle EP have been limited.

The Coimbra Municipal Housing Park (social housing) consists of 854 dwellings, with different typologies, integrating building apartments and houses dispersed over the city. The buildings were built before the first building code entered into force in 1990, and therefore those buildings do not have any thermal insulation. Part of the social housing park in the city centre has recently undergone some retrofits, but the actions taken were mainly on painting the façades. Hence, the existing potential for energy renovations is high. Moreover, a large share of inhabitants is elderly and low educated, who cannot afford to carry out improvements and construction works or do not have the knowledge on how to start the renovation journey, and therefore a holistic approach is required to have a high impact. Sound impartial advice on what is best for improving the overall environment and actions geared towards behavioural changes and capacity building can lead to significant improvements in households' well-being.

[4] https://www.eppedia.eu/article/energy-efficiency-housing-stock-portugal

[5] https://censos.ine.pt/xportal/xmain?xpgid=censos21_habitacao&xpid=CENSOS21

As can be seen in Figure 26, the periods before 1990 represent the highest levels of need for renovations to building structures, walls and façades; 50-65% of the buildings need renovations.

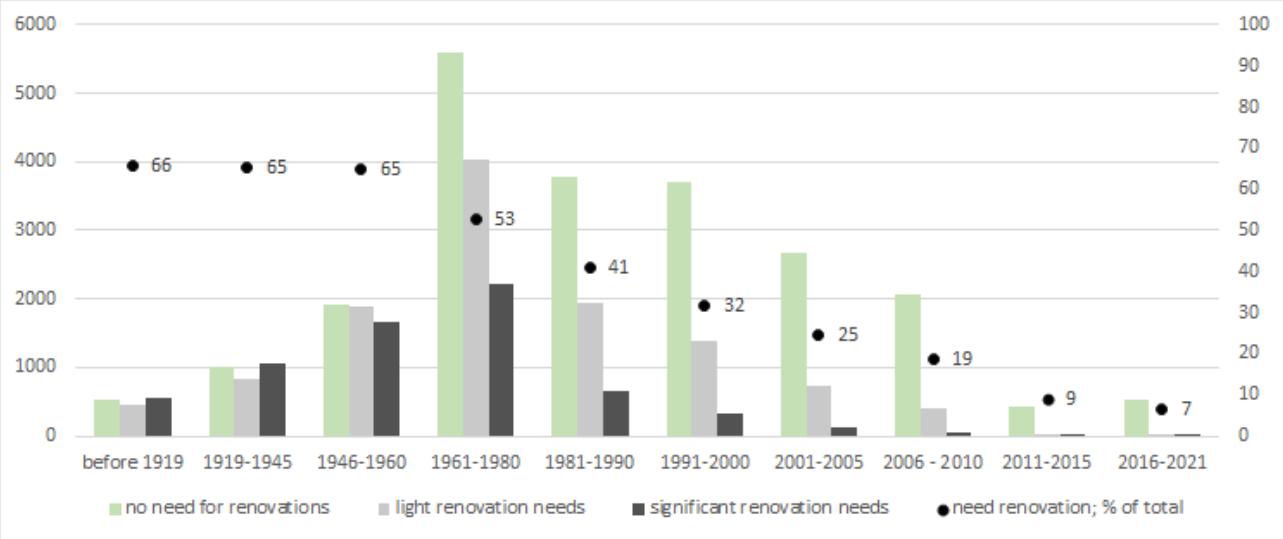


Figure 26: Medium/deep renovation needed to the structure, walls and window frames of buildings, in Coimbra Municipality (CENSUS 2021; INE).

Table 8 presents an overview of the number of residences by construction period, Table 9 and Table 10 of the repair needs for existing buildings for the Coimbra Municipality and urban area and Table 11 of the number of dwellings/residences by size.

Table 8. Number of residences by construction period in Coimbra Municipality.

	Total no. of buildings	Construction period							
		Before 1945	1946 - 1960	1961 - 1980	1981 - 1990	1991 - 2000	2001 - 2005	2006 - 2010	After 2011
Coimbra Municipality	40701	4431	5437	11841	6409	5428	3554	2537	1064
Coimbra Urban	16688	2150	2811	4501	2634	1959	1242	946	445

Repair needs for existing buildings, according to the period of construction, in Coimbra (Urban area and Municipality):

Table 9. Repair needs for existing buildings in Coimbra Municipality.

	Total	before 1945	1946-1960	1961-1980	1981-1990	1991-2000	2001-2005	2006-2010	After2010
No need for renovations	22226	523	1001	1906	5583	3790	3702	2680	3041
Light renovation needs	11746	445	832	1879	4033	1953	1387	741	476
Significant renovation needs	6729	562	1068	1652	2225	666	339	133	84

Table 10. Repair needs for existing buildings in Coimbra Urban area.

	Total	before 1945	1946-1960	1961-1980	1981-1990	1991-2000	2001-2005	2006-2010	After2010
No need for renovations	8689	739	1050	2017	1467	1296	912	791	417
Light renovation needs	5235	678	1014	1655	901	561	283	128	15
Significant renovation needs	2764	733	747	829	266	102	47	27	13

Table 11. Number of dwellings/residences by size (in m^2) in Coimbra region.

Area	Total no. of dwellings	Area (m^2)									
		Less than 40	40-49	50-59	60-69	70-79	80-89	90-99	100 -109	110 - 119	120+
Centre Region	907883	32825	31510	44420	100885	154589		167181		376473	
Coimbra Municipality	59940	2892	2697	3605	7512	10457		10493		22284	
Coimbra Urban	37571	2090	1862	2460	5132	7058		6668		12301*	

* more than 50% of these dwellings have areas above $150m^2$.

In the Coimbra Urban area, about 17% of dwellings are less than 60 m^2, 13,7% between 60 and 79 m^2, 18,8% between 80 and 99 m^2, and 17,7% between 100 and 120 m^2, 32,7% more than 120 m^2. As expected, the dwellings in the city tend to be smaller, but the difference is not very significant (Figure 27).

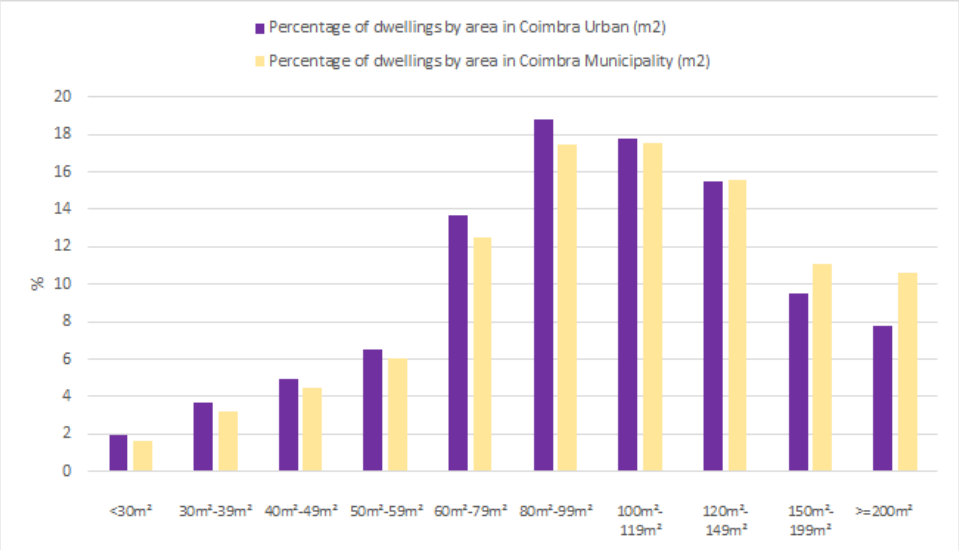


Figure 27. Distribution of dwellings by size in Coimbra urban area and the region.

A similar pattern is observed relative to the number of rooms (Figure 28). As expected, the city presents a slightly higher percentage of small dwellings (one to four rooms) than the Municipality.

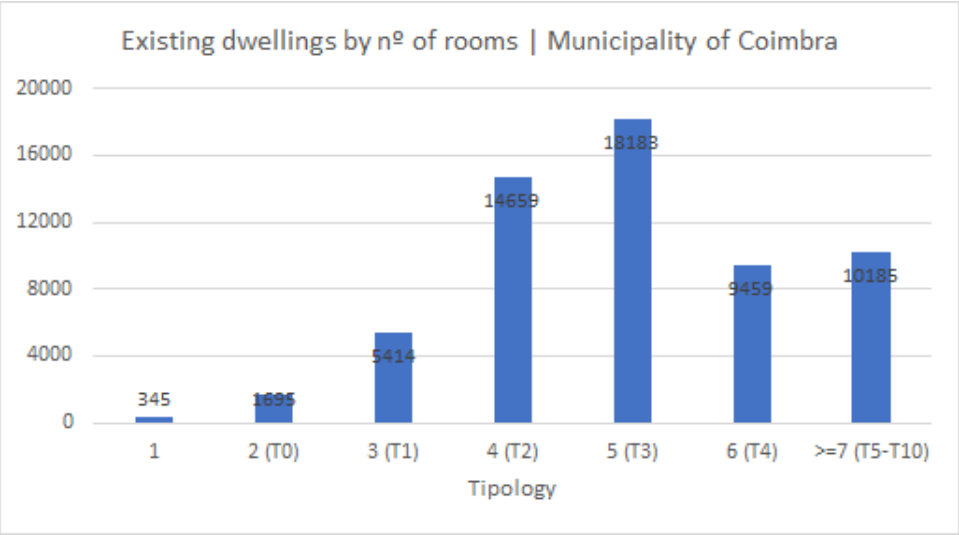


Figure 28. Distribution of dwellings by number of rooms in Coimbra Municipality.

4.2 Presentation of data from the energy performance certificates per building type

In order to get a more recent picture of the energy efficiency situation of the dwellings in Portugal, statistics from the Energy Performance of Buildings Certificates (EPBC) are presented in Figure 29,

which were retrieved from the LPRE. The analysis is based on more than 240 650 Building Certificates issued up to 2018.

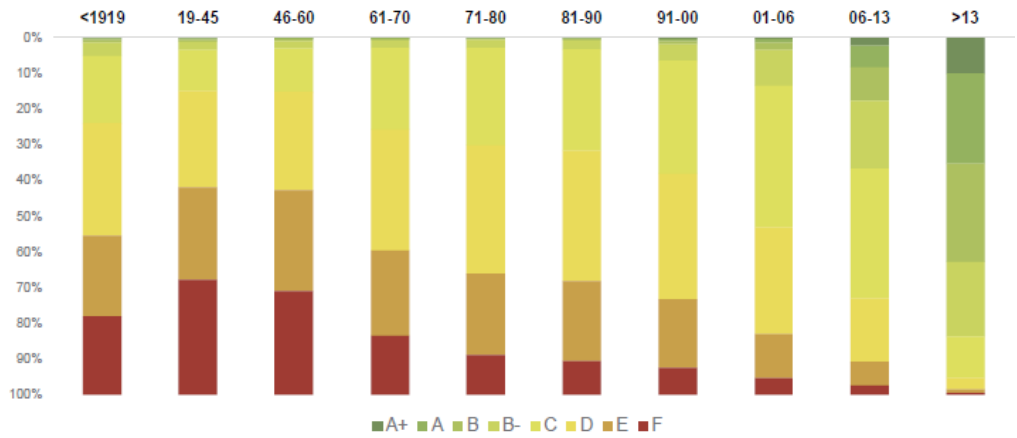


Figure 29. Energy performance of building stock in Portugal, by period of Construction (source: ADENE, as in the National Long Term Renovation Plan, RCM nº8A-2021).

As presented in Table 12 and Figure 30, 50% of dwellings in the area of the Coimbra pilot are classified in the three worst energy classes (D, E and F), about 20% in the middle energy classes (B- and C), and about 24% in the highest energy classes (A+ to B).

Table 12. Number of EPCs (housing) by energy class (2014-2023), in the Municipality of Coimbra[6].

	Energy class									
	A+	**A**	**B**	**B-**	**C**	**D**	**E**	**F**	**G**	**Total**
Coimbra Municipality	**1452**	**3127**	**1614**	**1719**	**5519**	**5956**	**4004**	**2595**		**25986**

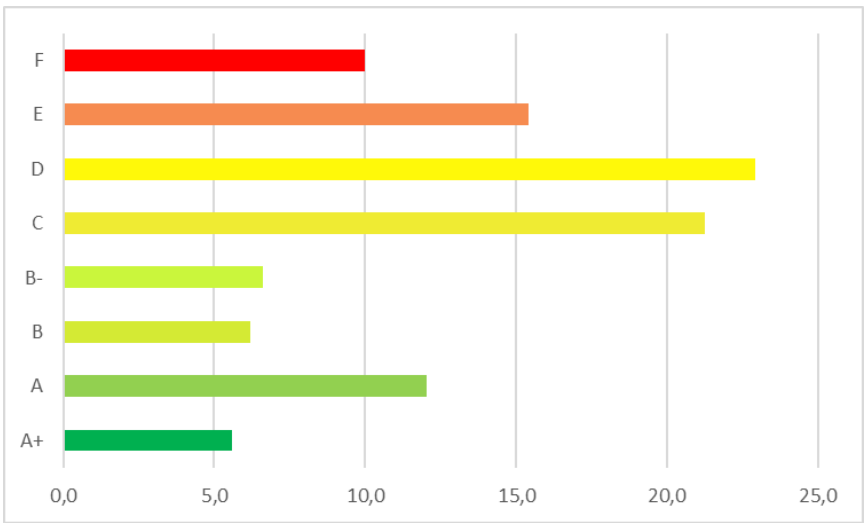


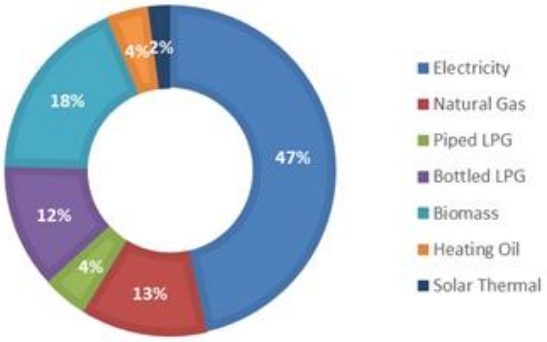
Figure 30. Disaggregation of issued Certificates in the Municipality of Coimbra (%).

[6] https://www.sce.pt/pesquisa-certificados/

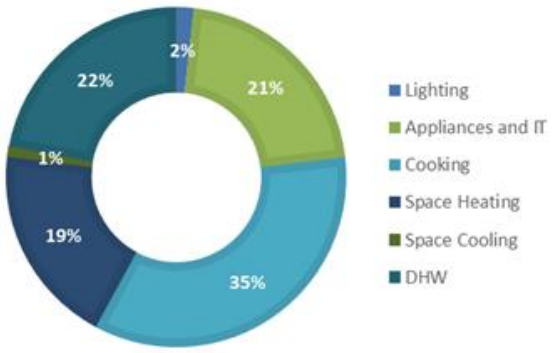
4.3 Information about the energy demand and the utilized fuels per building type

In Portugal, according to the most recent results available (INE, consumption survey 2020), energy consumption in the domestic sector confirms the trends identified from other sources of information, namely the increase in the relative weight of electricity and natural gas in domestic energy consumption and the existence of efficiency gains, partly associated with the type of equipment used.

As regards energy consumption (excluding fuels used in vehicles), in 2020 electricity remained the main source of energy consumed in the domestic sector in Portugal, accounting for 46.4% of total energy consumption (Figure 31). Biomass emerged as the second main source of energy consumed in Portuguese households in 2020, accounting for 18.4% of total energy consumption in homes. With regard to gas consumption in the domestic sector, this has been increasing since the expansion of the Natural Gas network in Portugal, being available for about 28% of dwellings in Portugal. Natural gas is the third main source of energy in the domestic sector in terms of consumption. Bottled LPG, despite being used in around 53% of households in Portugal, has dropped to fourth place in terms of energy consumption in the domestic sector, representing 12.2% of total energy used. Piped LPG, Heating Oil and Solar Thermal still have low expression (4.4%, 4.1% and 2.1% of total energy consumption in households in 2020, respectively), although Solar Thermal energy consumption almost tripled in the last decade.



Distribution of energy consumption in the dwelling by type of energy in Portugal (Source: INE 2020)



Distribution of energy consumption in the dwelling by type of main end-use (Source: INE 2020)

Figure 31. Distribution of energy consumption in the dwellings in Portugal.

Electricity consumption plays a very important role in the residential sector, since most of the equipment in homes requires this type of energy, and there is a clear dependence on this energy source in today's society. Electricity consumption is directly associated with the increase in thermal comfort and the growth in the number of electrical appliances available in homes, but also with the availability of more efficient equipment in terms of consumption.

Considering the type of end use of electricity, consumption in the kitchen and electrical equipment was the highest, accounting for 42.7% and 46.0% respectively of total electricity consumption in 2020 (Figure 32).

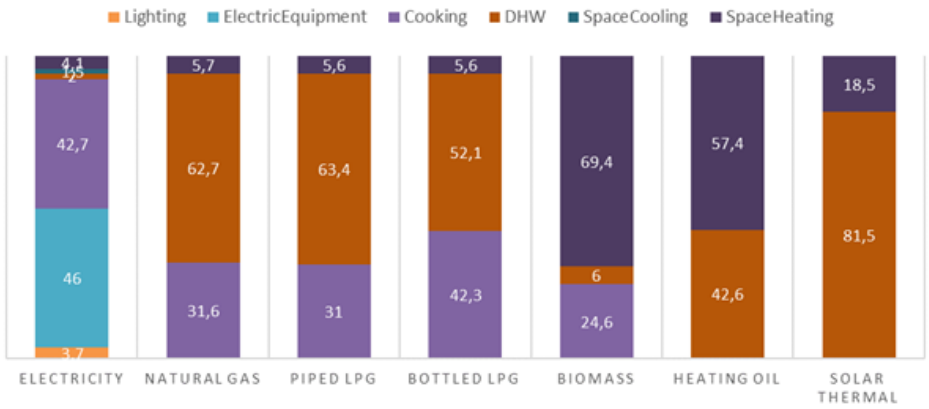


Figure 32. Distribution of energy consumption in the dwelling by energy source and type in Portugal (Source: INE2020).

Based on the above information and taking into account field auditing studies, the typical household electricity consumption, broken down by the main uses in the dwellings, can be estimated with a good degree of confidence, as presented below. Lighting and electrical appliances had more than half of the consumed electricity, while the other end-uses resulted in shares ranging from 8% for the case of space heating to 16% for the case of domestic hot water (Figure 33).

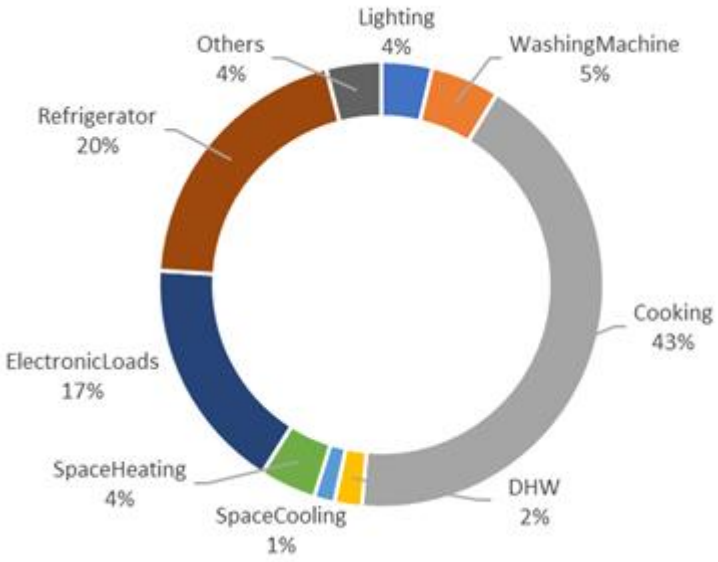


Figure 33. Distribution of the electricity consumption in the dwelling by end-use in Portugal (adapted based on cross references).

Electricity was the most prevailing energy carrier representing 40% of the total energy consumption according to the presented data in Figure 32. Renewables, including biomass, had also a significant share (37%), while the penetration of oil products and natural gas was 13% and 10%, respectively. The shares of the other energy carriers were low.

Natural gas, bottled and piped LPG are mostly used for DHW and for cooking. Biomass and heating oil are mostly used for space heating. Regarding solar thermal, it has a significant contribution to DHW production, while electricity penetration for DHW production is marginal.

4.4 Analysis of the energy poverty levels per building type in Coimbra

The EP indicators are investigated with respect to certain housing features and living conditions to explore the effect of the last ones on EP vulnerability in the pilot area.

Below, the relationship between EP vulnerability and certain housing features, as well as living conditions, is explored. As shown in Figure 34, households living in semi-detached houses face the highest problems with leaks/damp walls, while they are less prone to arrears, and are more capable of keeping their house adequately warm. Households living in apartments (small buildings, followed by large buildings) present lower EP issues, on average, as compared to the average rates.

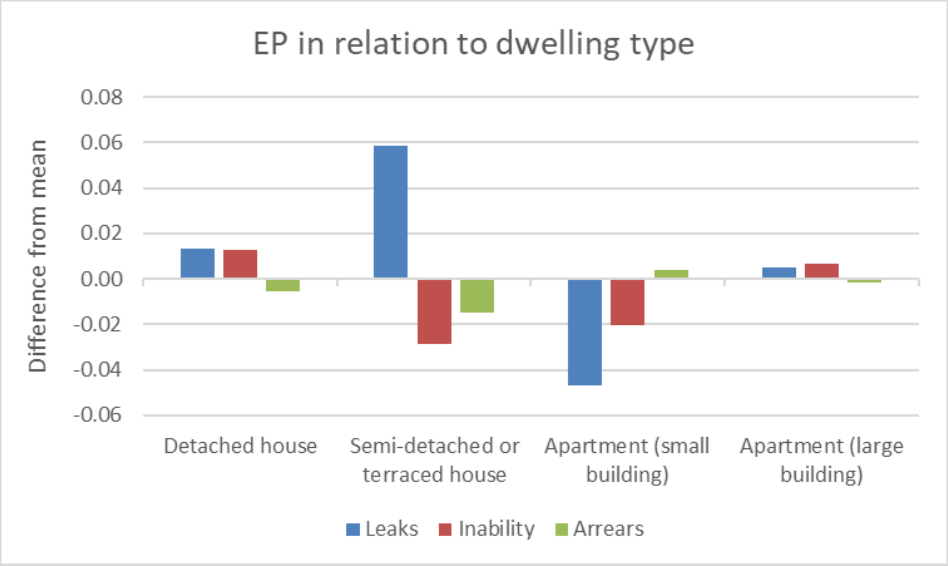


Figure 34. Leaks, inability to keep the house warm and arrears on utility bills in relation to dwelling type.

The dwelling size is also related to the three basic EP indicators, as shown in Figure 35. Households living in one-room houses present the highest problems in terms of leaks/damp walls compared to the average, while they are less prone to the other two indicators, on average. Households living in houses with four or more rooms have the lowest EP rates, probably due to the income of these households.

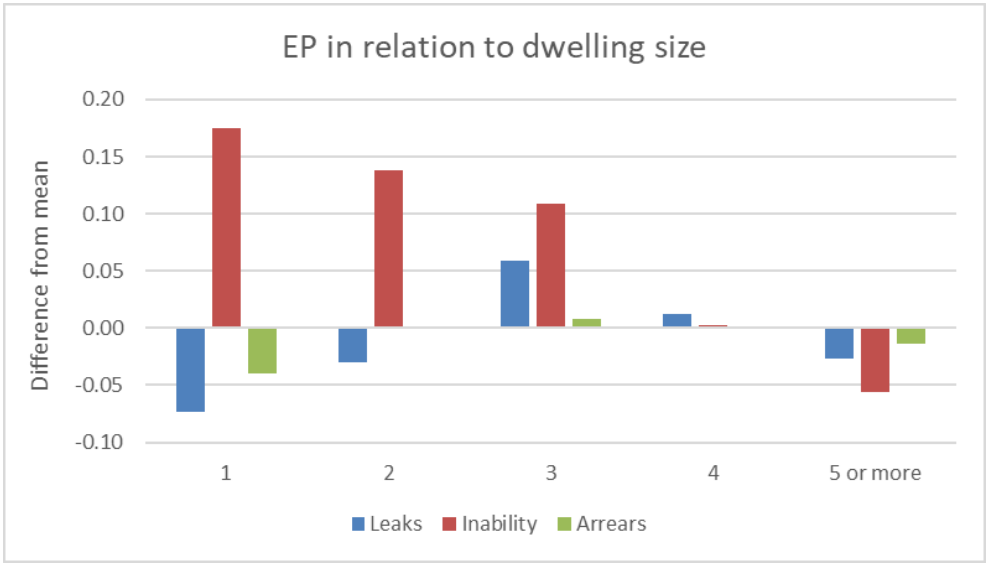


Figure 35. Leaks, inability to keep the house warm and arrears on utility bills in relation to dwelling size.

Regarding tenure status Figure 36, the most vulnerable groups to EP are tenants who pay rent (either at the market or at a reduced rate) and households living in free accommodation. It should be noted though that tenants who pay rent at a reduced rate are the most vulnerable ones in terms of keeping their home adequately warm.

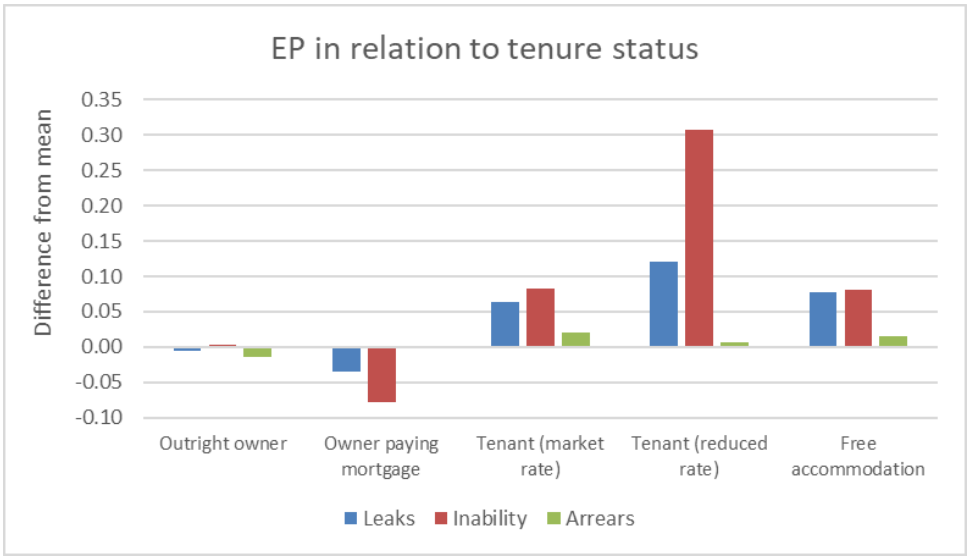


Figure 36. Leaks, inability to keep the house warm and arrears on utility bills in relation to tenure status.

Figure 37 shows that households experiencing difficulty and great difficulty in making ends meet face also higher EP issues, with differences in EP rates of up to 25% in comparison with average rates. On the other hand, households that can easily make ends meet present quite lower EP rates, of up to 15% versus average rates.

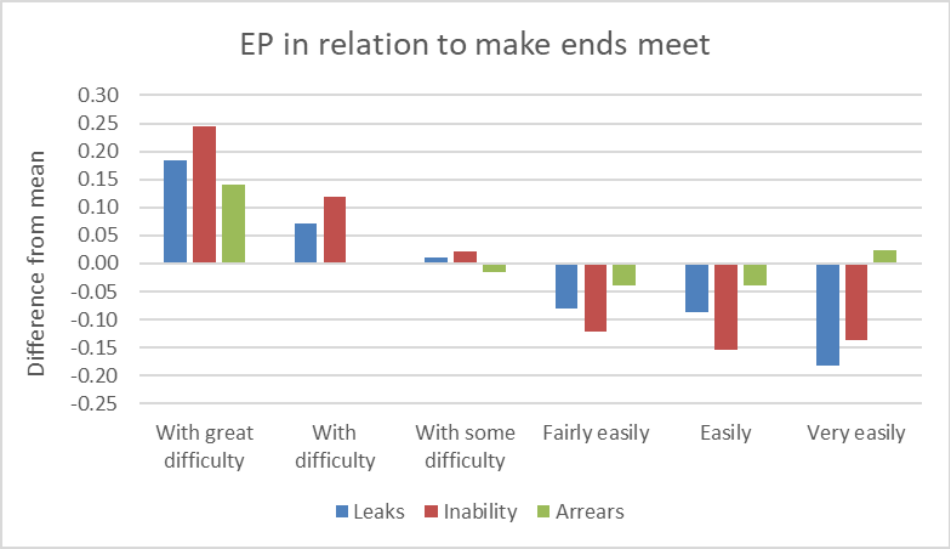


Figure 37. Leaks, inability to keep the house warm and arrears on utility bills in relation to the level of difficulty in making ends meet.

As regards complementary EP indicators and certain housing features examined, it is shown that households living in small buildings are less prone to EP problems compared to the average rates (Figure 38), while households living in two and three-room houses are more energy-vulnerable (Figure 39). Tenants and those living at free accommodation status face higher EP issues (Figure 40), as also happens with households that face difficulty in making ends meet (**Error! Reference source not found.**).

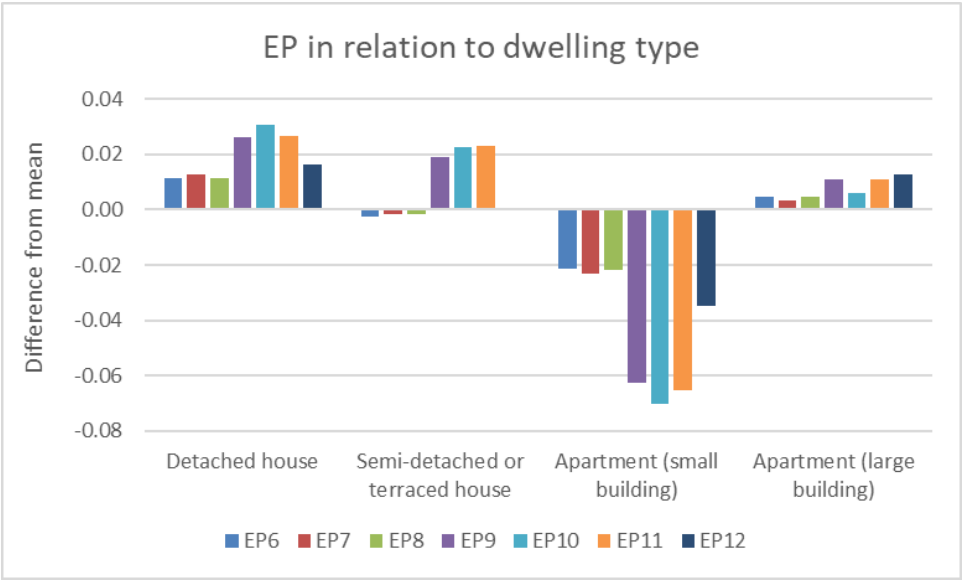


Figure 38. Complementary EP indicators in relation to dwelling type.

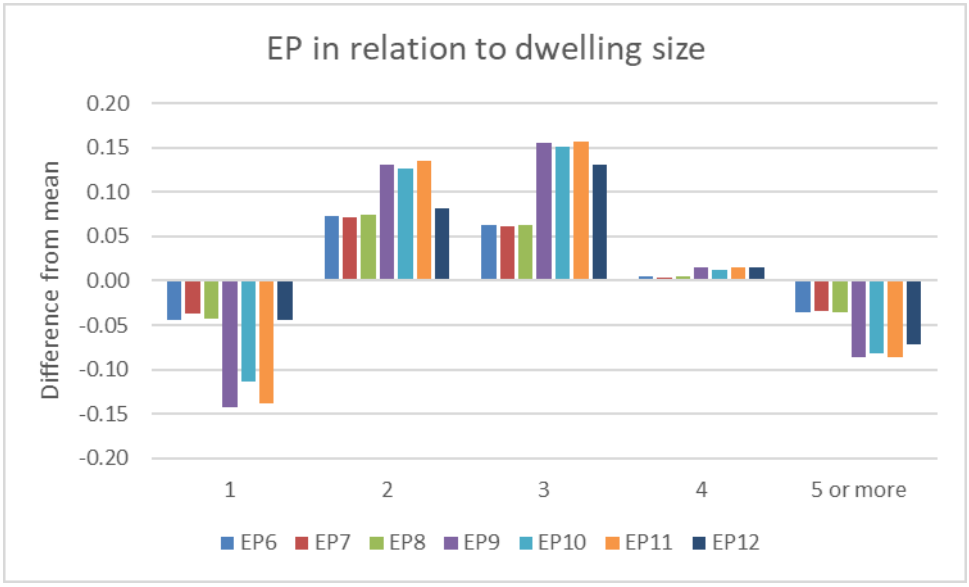


Figure 39. Complementary EP indicators in relation to dwelling size.

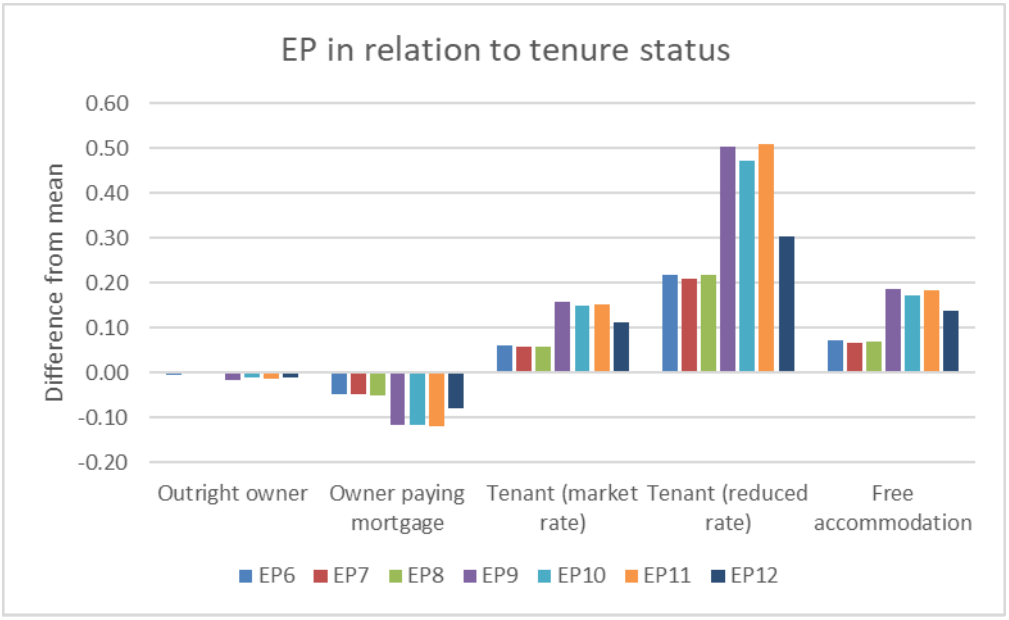


Figure 40. Complementary EP indicators in relation to tenure status.

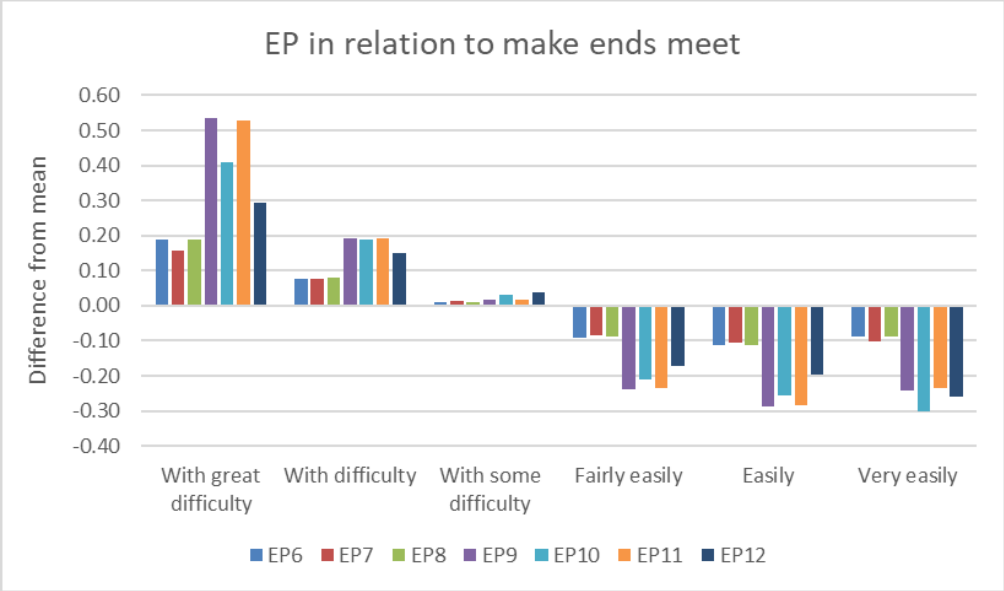


Figure 41. Complementary EP indicators in relation to the level of difficulty in making ends meet.

Table 13 presents the energy Poverty levels, according to the main indicators used in Portugal.

Table 13. Energy Poverty levels, according to the main indicators used in Portugal (from Long-term strategy to mitigate energy poverty, based on INE references).

Indicator	Value	Reference
(IP1.1) Population living in households without the capacity to keep the house adequately heated...	17.5% (about 1.8 million of people)	2020 (INE, I. P.)
(IP1.2) Population in a situation of poverty and living in households without the capacity to keep their homes adequately heated...	33.8 % (about 609 thousand people)	2020 (INE, I. P.)
(IP2) Energy performance of homes...	69.6% (efficiency class C or below)	2020 (ADENE)
(IP3.1) Population living in homes with problems of infiltration, humidity or rotting elements...	25.2% (about 2.6 million of people)	2020 (INE, I. P.)
(IP3.2) Population in a situation of poverty and living in homes with problems of infiltration, damp or rotting elements...	36.4% (about 944 thousand people)	2020 (INE, I. P.)
(IP4) Population living in housing that is not comfortably cool during the summer...	35.7% (about 3.7 million of people)	2012 (INE, I. P.)
(IP5.1) Population in households whose energy expenditure represents +10% of total income...	1 202 567 (about 3.0 million of people)	2016 (INE, I. P.)
(IP5.2) Households in poverty whose energy expenditure represents +10% of total income...	263 033 (about 660 thousand people)	2016 (INE, I. P.)

4.5 Identification and analysis of existing policies, strategies or investments planned for the pilot area so as to renovate the building stock

Among the overall political factors, the national framework is aligned with European Directives, going further in the reduction targets established in the long term. The Portuguese government aims to achieve carbon neutrality by 2045. There is no definition of deep renovation but the National Energy and Climate Plan and the Long-term Renovation Plans, together with the recently approved National Strategy for Energy Poverty, are important drivers to increase building renovation rates, thus creating a favourable framework for the diffusion of the REVERTER roadmaps. Local regulations at the Municipal level often limit the scope of renovation possibilities due to specific requirements for the façades, etc., (e.g. Municipal Masterplan and Municipal Urbanisation and Building Regulations) as well as there are too many formalities (licenses, etc. ...) to start the process. This implies a long process for each individual procedure. Time and bureaucracy are important barriers for renovations.

The Portuguese Long-Term Renovation Strategy, issued in February 2021, promotes building renovation through indicative objectives of renovations, primary energy savings and a reduction of hours of discomfort for 2030, 2040 and 2050. The strategy also defines measures to support the achievement of these objectives.

As part of ELPRE, a package of measures was presented aimed at improving comfort and mitigating energy poverty, which aims to act at the level of the thermal envelope of buildings in order to guarantee acceptable levels of comfort without increasing energy consumption for heating. Specifically, these actions would be carried out in two phases:

1) by 2030, to be implemented in residential buildings with the worst energy performance, namely permanent dwellings built before 1990, corresponding to 65 % of the national stock of residential buildings existing in 2018;
2) by 2040, in the remaining residential buildings built before 2016, corresponding to almost 100 % of the national stock of existing buildings in 2018.

Realising this goal, considering the estimated investment values, will represent an investment of 7671 million euros by 2040, around 384 million euros per year, which will make it possible to considerably reduce energy poverty by renovating the building stock.

In relation to financing help for building renovations, there are National Incentives and interesting instruments for lending funds for renovation works (IFRRU and 1º Direito), as well as specific financial incentives for low-income families, such as the energy efficiency vouchers, available since November 22, which can amount to 3900€ per household and there is also VAT reduction for energy renovations. The central government has also been promoting the use of RES by low-income households, by creating the regulatory framework for the establishment of REC. Transposition of new targets regarding energy savings (new EED recently approved with new yearly reduction targets), and the ongoing revision of the EPBD, setting more ambitious targets and requirements such as the MEPS for existing buildings, will ensure the ongoing efforts to improve the building stock, starting with the most energy

inefficient buildings. At the local level, several municipalities already developed the Local Strategy for Housing and their SECAPs.

While the social energy tariff is typically identified as an appropriate measure to combat energy poverty, existing programmes addressing EP in Portugal are using it as eligibility criteria to provide grants to vulnerable households. For example, households that are already recipients of the Social Energy Tarif mechanism (eligibility criteria) are eligible to get financial incentives so that they can invest in improving the thermal comfort of their homes.

A social tariff is a support granted to consumers in a situation of economic deprivation to help them decrease the burden on their energy costs, electricity and gas. For instance, solidarity supplements for the elderly, social re-insertion subsidies, Social Integration Income, those receiving unemployment benefits or old age pensions, family allowances, social disability pensioners, and supplements to the social benefit for inclusion, are entitled to the social tariff. In addition, those with an annual income of up to 5808 euros, increased by 50% for each element of the household without income, up to a maximum of 10 people.

The main aim of the social tariff is to help reduce the amount to be paid in monthly electricity and natural gas bills of consumers in a situation of economic deprivation. This support works through a percentage discount on the energy bill, published annually by the regulator ERSE. The social tariff discount is the same for all eligible consumers, regardless of whether they are in the regulated or liberalised market. However, the percentage applied is different for electricity and natural gas.

5 PESTEL Analysis

A PESTEL analysis was conducted to identify the most important parameters and the main market barriers and market failures (administrative, financial, technical, awareness, and others) in the pilot area.

The PESTEL analysis consisted of the following steps:

- Step 1: Speculate the PESTEL factors
- Step 2: Identify and map all the relevant PESTEL factors
- Step 3: Assess the level of impact of PESTEL factors
- Step 4: Identify opportunities and threats
- Step 5: Select the most effective policies and measures

The PESTEL analysis for deep renovation measures in residential buildings and social housing, for both typologies, namely multi-apartment buildings and single-family houses, reveals several critical external factors that affect building renovation roadmaps. Among the overall political factors, the national framework is aligned with European Directives, going further in the reduction targets established in the long term.

The Portuguese government aims to achieve carbon neutrality by 2045. There is no definition of deep renovation, but the National Energy and Climate Plan and the Long-term Renovation Plans, together with the recently approved National Strategy for Energy Poverty, are important drivers to increase building renovation rates, thus creating a favourable framework for the diffusion of the REVERTER roadmaps. Local regulations at the Municipal level often limit the scope of renovation possibilities due to specific requirements for the façades, etc., (e.g. Municipal Masterplan and Municipal Urbanisation and Building Regulations) as well as there are too many formalities (licenses, etc. ...) to start the process. This implies a long process for each individual procedure. Time and bureaucracy are important barriers for the roadmaps to be implemented in a short time.

In relation to financing help for building renovations, there are National Incentives and interesting instruments for lending funds for renovation works (IFRRU and 1º Direito), as well as specific financial incentives for low-income families, such as the energy efficiency vouchers, available since November 22, which can amount to 3900€ per household and there is also VAT reduction for energy renovations. The central government has also been promoting the use of RES by low-income households, by creating the regulatory framework for the establishment of REC. Transposition of new targets regarding energy savings (new EED recently approved with new yearly reduction targets), and the ongoing revision of the EPBD, setting more ambitious targets and requirements such as the MEPS for existing buildings, will ensure the ongoing efforts to improve the building stock, starting with the most energy inefficient buildings. At the local level, several municipalities have already developed the Local Strategy for Housing and the SECAPs.

In terms of regulation, Portugal is well advanced, yet the bureaucracy and complexity behind the processes postpone the household decision to enter into a renovation process by themselves. If the roadmaps are embraced by the Municipalities and included under Urban Planning, then the constraints for improving the building stock are lessened. A roadmap

defining a common intervention framework will guide commercial companies and facilitate comparisons by clients, increasing the demand for energy renovation services, and thus promoting economic competitiveness and innovation.

The lack of relevant stakeholders to deliver renovation works at reasonable cost and quality, the lack of know-how and acceptability from households, who still do not trust in services being provided by ESCOs, the cultural habits of living in a mild country weather, among other factors such as tenure of the house, do not motivate households to invest in the house. Projects Aggregation by ESCOs in collaboration with housing departments of the municipalities, can have a significant impact in lowering the cost of renovation with high impact in the roadmaps. However, the ESCO market is not yet well developed in this area in Portugal, particularly in the offering of services for the residential sector.

In conclusion, the relatively mild climate (households may consider it normal and acceptable to feel both cold and hot at home, either in winter or in summer), the low household income, the high electricity costs, and the low level of literacy among the lowest income, explain the rationale when it comes to managing the household budget leaving many households to live in Energy Poverty, a significant problem that tends to increase in the present socio-economic situation Portugal is facing. Being the front runner in terms of renewable energy production, in terms of policy framework, implementation of legislation and social support does not mean there is a sound field implementation, and therefore the policies have little effect on improving the living conditions of the population.

Table 14 presents the factors that affect the preparation of the building renovation roadmap.

Table 14. Identification and assessment of the factors, which affect the building renovation roadmap.

	External factors to consider	Factors affect building renovation roadmaps	Importance to the renovation roadmap (High-medium-low)
Political	***EU directives focused on 2050***	The definition of Deep renovation is still missing (will be provided by the New EPBD 2023). EPBD-recast 2023 finally includes adjacent Directives and 2050 goals (circularity, roadmaps, district scale approaches, ...) National Energy and Climate Plan and Long-term Renovation Plans, establishing national targets for renovation of buildings, tackling Energy Poverty.	High: "green" and "innovation" Procurement requirements to be considered in the renovation roadmap
	Governance structures (e.g., formal or non-formal structures that support governance	Local regulations at the Municipal level often limit the scope of possibilities due to specific requirements for the façades, etc., (PDM, RMUE) and also there are too many formalities (licenses, etc. ...) for preparing the process. This implies a long approval process for each individual. New Housing Plan for the country is being negotiated between parties; At the local level, the bureaucracy and time to obtain	High: "Deep Renovation Roadmaps" for a neighbourhood scale (guiding roadmap, not mandatory) could set a streamlined strategy at the municipal level, particularly for Social Housing.

		licenses is a major hindering factor for roadmaps to be implemented.	
	Incentives/Financial Measures	European renovation strategies prioritize buying new highly efficient solutions, a linear process, without comparing with lower carbon solutions like improving what already exists; There are National Incentives for building renovations (IFRU and 1º Direito), as well as financial incentives for low-income families with a social tariff (EE vouchers amounting to 3900€), VAT reduction for energy renovations, and promotion of REC involving the most vulnerable.	High: Support for low-income families mandated in EPBD 2023 may foster new solutions for EP mitigation
	Pending legislation changes	Transposition of new targets regarding energy savings (new EED approved with new yearly reduction targets), and EPBD still under revision, but more ambitious targets and requirements: MEPS will be introduced for existing buildings, which ensures the continual improvement of building stock, starting with the most energy inefficient buildings)	High: the "2050 direction" requires REVERTER to be ambitious in the replication and exploitation
	Policy goals/specified national targets (e.g., in energy, environment, regional development)	Local Strategy for Housing is being revised and the SECAP is being developed. Adoption of Long-Term Strategy to Energy Poverty (in due time).	Medium
	Political stability and remuneration framework	A new government will be elected in March, which can introduce differences in the future.	Medium
Economic	***Availability of lending funds***	Instruments exist, like IFRRU, but are not easy to access by individuals; Instruments for social buildings have funds available, and a significant investment by PRR, yet processes are always "urgent", and often "first-come, first-served	High: Obligation to match local needs with national funding priorities
Eco	***Capacity of construction and energy sector***	Adequate training to fit 2050 goals is missing: check your workforce, and you will see that integration is absent Lack of workforce, particularly for the installation of heat pumps; The market is not ready for the roll-out of heat pumps (training and supply chain)	Medium: Anticipate onsite initial training to reach desired outcomes;
Eco	***Competitiveness***	A roadmap defining a common intervention framework will guide companies, and facilitate comparisons by clients. Increasing demand will promote competitiveness, particularly for Energy Efficiency measures, but also for PVs and renovation works (Rockwool, for e.g.). Also, innovation can be promoted.	High: Guiding the market will scale REVERTER's results

Eco	***Cost of living***	The cost of living affects the investment capacity; on the other hand, lower energy and maintenance bills reduce the cost of living For EP, high inflation is hindering potential investments in other things than basic needs. On the other hand, with proper incentives and policies, vulnerable people may adhere to the renovations if they understand well the impact on their energy bills and quality of life.	Medium: Yet make sure that in the end, a roadmap delivers lower operational costs, both economic and environmental
Eco	***Demand for building renovation and energy services***	Very limited demand; bathroom and kitchen renovations still prevail. Increased interest in energy services and renovations by those in EP if RRP and social funds are channelled correctly to those who really need them.	High: As stated in our Agreement"
Eco	***Economic development patterns (future trend)***	Innovation will bring to the market cost-effective solutions; The economic situation of the country is going more or less well, so the expectation is quite positive. Several municipalities are developing SECAPs and focusing on EP as well.	High The adoption of renovation measures is favoured by the economic development patterns foreseen in the near future. Increasing digitization implies significant changes and options for new approaches.
Eco	***Economic growth/decline (current status)***	Unpredictable economic development, due to political instability in the country, has a strong impact on the chosen solutions, particularly the solutions with higher upfront costs that may suffer in an environment of economic decline or refrain.	High
Eco	***Energy expenses***	Energy expenses share a relatively high percentage of households' budget, particularly for low-income households, but do not drive the demand for renovation works because of cultural and habit issues: people are used to feeling cold in winter and this is a norm, mainly due to the relatively mild weather.	Medium
Eco	***Energy prices***	Energy prices are relatively high for the Purchase Power, but do not drive the demand for renovation works, because of the relatively mild weather.	Medium More impact in the chosen solutions than in the roadmap in itself

Eco	***Energy services companies***	Lack of relevant stakeholders to deliver; lack of know-how and acceptability from households, who still do not trust in services being provided by ESCOs. Project aggregation by ESCOs can have a significant impact in lowering the cost of renovation with a high impact on the roadmaps. However, the ESCO market is not yet well developed in this area, particularly in the offering of services for the residential sector.	High: need to guarantee adequate onboarding
Eco	***Energy taxation***	Higher energy prices may affect the willingness for renovation works to be carried out.	Medium
Eco	***Inflation/deflation / progressive cost reductions***	Tendency to postpone investments; uncertainty; price revisions; Higher prices decrease the already low investment capacity of families; So lack of interest in renovation roadmaps	Low
Eco	***Interest rates***	Reduced investment attractiveness; Added risks; Interest rates have increased significantly in recent years and therefore are not an incentive for lending money from the bank. On the other hand, having money in the bank is not a good investment. Therefore, some people will realize the good investment that it is to invest in the house (increase property value). Availability of low-cost finance is one of the primary means of unblocking energy efficiency renovation, as the upfront cost is one of the major barriers, together with the complex process	Medium
Eco	***Labour costs***	Uncertainty; price revisions; the type of intervention is greatly influenced by the cost component of labour;	Medium
Eco	***Prevailing economic sectors in terms of GVA with competitive advantages***	Tourism has put strong pressure on the real estate market, thus contributing to the actual housing crisis, particularly in larger cities. The incentives being provided for building renovations if the building was available for local renting, has put many houses in a competitive advantage to access funds. This is a potential niche market for DEEP renovation roadmaps. However, the service sector is prevalent.	Low for our roadmaps. However, there is a potential for deep energy renovations. Real interest in getting a more serious role from these actors
Eco	***Skilled energy efficiency professionals***	Lack of professionals Lack of trained professionals, then higher market prices. Many, yet dispersed demand increases individual intervention prices	High: Solutions to optimize the use of the most skilled workforce; peer training Scale in interventions to

			reduce non-productive time
Eco	***Split incentives***	Owners do not yet realize the added value of the property by doing renovations, and since they don´t pay for the bill, they are not motivated to act. Fiscal incentives for owners (tax reductions, ….)	High
Eco	***Unemployment***	Lower-income availability; Increased energy needs while staying home all day.	Medium: This is a way to characterize our target population
Eco	***Financing renovation interventions***	Low saving capacity in Portugal = low investment capacity for renovation = low debt capacity = no action	High
Social	***Career attitudes***	There is not enough attraction to green jobs, but the roadmaps can foster the demand for energy services and therefore green jobs as well.	High
Social	***Demographics***	Portugal, and Coimbra, are among the regions with a considerably aged population, who are less interested in investing in renovation works.	High: The aging population is, most of the time, our target but also an interesting source of ambassadors
Social	***Energy consumption & production patterns***	Limited access to data (GPRD) limits the diversification of supply services and interaction with end-users, but as a services city, the load profile within households is more or less known, and the potential for developing energy services, including demand response, should be high.	Medium
Social	***Institutional capacity***	Renovation is seen as a burden for households and a complex process. Institutions do not have skilled staff or availability to help citizens with the renovation processes. The roadmaps can be able to demonstrate that it does not have to be complicated and messy.	High
Social	***Level of awareness on delivered impacts by RES and energy efficiency***	There is still a strong lack of knowledge about RES and its impacts on the bills. Lay people, and even well-educated people, do not understand the difference between RES and Energy Efficiency, and their choices are mainly driven by appearance and their beliefs in terms of climate change impacts.	Medium More impact in the chosen solutions than in the roadmap in itself
Social	***Lifestyle factors***	Shifting from gas (mainly for cooking and DWH) to electricity improves indoor air quality and health benefits. Natural mistrust towards new coming solutions particularly towards services.	Medium
Social	***Participatory culture***	Very limited participatory culture and mistrust towards collective actions;	High: participation is essential for engagement and

			often makes costs smaller
Social	***Population***	Non-diversified social housing limits entry points and results	High: important to answer to this population, and to a more diversified one to ensure replicability
Social	***Rates and characteristics of energy poverty in the population***	There is a high rate of EP in Coimbra. The targeted population has low literacy, energetic but not only, but also digital illiteracy is a common issue. The project will help them to understand the impacts of improving indoor comfort, even low-cost measures that can improve significantly their well-being.	High
Social	***Rates and characteristics of general poverty in the population***	High poverty. People who are quite vulnerable and receive social funds. Lack of awareness and trust from this target audience may have negative impacts on the acceptance of the renovations.	Low for our roadmaps, as the target is social housing.
Social	***Resistance to change***	Vulnerable community, with many gypsies. High resistance to change and there is a need to build trust in this community.	High
Social	***Role of prosumers***	No prosumers exist in the pilot areas. The inclusion of other actors would be a challenge but community-based energy is gaining momentum in Portugal, tackling energy poverty.	High
Social	***Social capacity***	Limited willingness to participate in collective actions; the sense of community is not widespread in Portugal and there is high resistance to being involved in participatory/collaborative actions. resistant to collective actions often explained by the condominium (bad) experiences in MFB: high costs and low regulations often result in conflict and inaction until extreme decay.	Medium-low
Social	***Society's levels of health, education, and social mobility***	Our EP population is on the lower edge: low level of education, unemployed, ethnic minorities.	High, because we are addressing social housing.
Social	***Work-life balance***	Informed decision-making processes take too much time and impose stress on people, yet better indoor conditions alleviate people's stresses and improve welfare.	Medium
Technology	***Artificial Intelligence***	high impact to help identify EP hotspots and map Energy Efficiency buildings, supporting local actions and better policies.	High
Tec	***Automation***	May be useful for smart houses, and easy to install, particularly for controlling window blinders, but it is out of the scope of this project and many households are reluctant and lack the knowledge to use automation and digitalization. These technological	Low

		improvements, while inevitable in the future, still pose many challenges for households to adopt.	
Tec	***Degree of digitalization of the energy sector***	Smart meters and RES platforms are available, but digital and energy illiteracy in association with the above factors are a cornerstone	Low
Tec	***Disruptive technologies***	Early adopters in the target group, if any, are not motivated for energy issues.	Low for our roadmaps, as the target is social housing.
Tec	***Innovation***	Innovation is associated with complexity, new learnings, and expensive stuff. Constant innovation may delay decision-making, yet is important for improving competitiveness.	High
Tec	***New energy-saving technologies***	Distrust (new) and high upfront costs; reluctance to change	High: Need to watch and include those that solve our problems
Tec	***Renewables technologies***	May hinder renovation works if promoted alone; Energy Efficiency first needs to be the First step; should be combined with energy efficiency renovation works to impact renovation roadmaps.	High: renewables are the way to go towards energy justice
Tec	***Smart city platforms***	The public transportation in Coimbra is going under big development within the concept of a smart city. Access to relevant information will be a crucial factor for the successful implementation of the roadmaps in connection also to mobility.	High
Tec	***Smart meters deployment***	Roll out of smart meters is ongoing and the coverage is already very high; the problem could be the communication with the aggregator in some areas. Consumers can request access to their data; the main problem is the illiteracy and capacity to understand the information, so there is still a lack of interest from consumers that the utilities need to tackle for the well of all.	Low
Environment	***Adaptation policies***	The building policy framework has been traditionally focused on climate change. The actions have been towards fighting climate change. It is now time to think about our buildings for climate adaptation. But no one can guess the prediction! There is limited knowledge to transform buildings to resist the unpredictable conditions of climate change.	High
Env	***Circular economy***	Most of the "deep renovation" available strategies and financing opportunities imply a replacement or addition of high embodied energy materials	High

Env	***CSR (Corporate social responsibility)***	Social Companies and utilities have a strong CSR sense and strong power to mobilize stakeholders and policymakers for action.	High
Env	***Environmental objectives***	Portugal has compromised to zero emissions by 2045, 5 years before the target imposed by the EC.	Medium
Env	***Environmental programs / partnerships***	The Environmental Fund, under the call for proposals, is providing incentives for building renovations, and also some subsidies have been distributed in the scope of the PRR, amounting to 85% of the investment within certain limits, for PVs, heat Pumps and Building Insulation.	High: if the call opens again
Env	***Environmental restrictions imposed by in-country governments***	Restrictive environmental regulations exist at the national level, favouring energy renovations.	Medium
Env	***Ethical sourcing***	Increasing visibility and responsibility for each phase of the supply chain	Low
Env	***Future pandemics***	Covid taught us the importance of indoor conditions: adequate space and air quality came on top of the agendas. Households realise how important is living space;	Medium
Env	***Procurement***	Green procurement is in force for public purchases (and the Municipality has to follow the procedures)	High
	Sustainable energy resources/potential	Most of the buildings were built before the first thermal building code, therefore the potential for improvements and energy savings is high.	High
	Transportation	Opportunity to integrate other needs	Low
	Waste management	National rules are tight and waste needs to be tackled adequately; it is mandatory to be included in the calculations	High
Legal	***Common law***	No legal framing for roadmaps exists. Need for revision of national laws to be harmonized with the sustainable goals and the energy and climate targets, and the new EPDB.	High
Legal	***Data protection law***	GDPR needs to be ensured accordingly	Low
Legal	***Employment law***		
Legal	***Health and safety regulations***	All health and safety regulations must be accomplished even if they may delay the work and or increase the costs. Evaluation of risks needs to be considered.	High
Legal	***Legislative and regulatory framework (e.g., for energy, spatial planning, environment, regional development)***	Municipal regulations imposing local requirements, for example for the façades: RJUE, RMUE, DL 37/2018 (1ºDireito), PDM, PRR, …..; National regulations like LTRS and NECPs (consideration of LCA and embodied energy to be considered).	High

Legal	***Level of compliance with the laws***	Need for updating, simplifying and optimizing the legislative and regulatory framework according to NECP	High
Legal	***Local labour law***		
Legal	***Laws & regulations on permissions and licenses (e.g., for renewables installations, buildings, production sites etc)***	There are strict rules in Portugal. the adoption of the required laws and regulations on permissions and licenses is ensured within the REVERTER, through the involvement of the Municipality.	High

6 Roadmap

6.1 Methodological approach

The building renovation roadmap resulted from the implementation of a methodological approach, which consisted of four different steps (Figure 42).

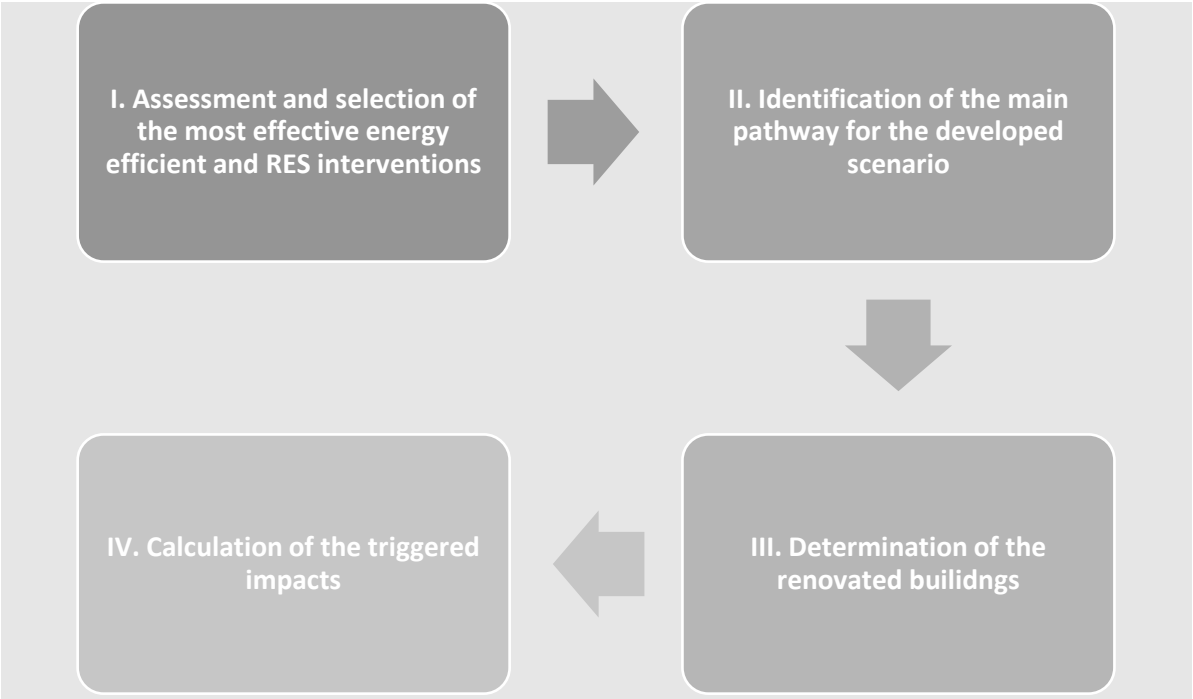


Figure 42. Applied methodological approach.

Firstly, the assessment and selection of the available energy-efficient and RES interventions occurred in Step I. Three different combinations of energy efficient and RES interventions were modelled in order to evaluate their performance and to select the most cost-effective one taking into consideration the cost-effectiveness ratio based on the delivered energy savings and CO_2 emission reduction. The main pathway for combating energy poverty through the renovation of the building stock was identified in Step II taking into account the selected energy efficient and RES interventions within the framework of Step I. Moreover, the number of renovated buildings was calculated for the formulated pathway in Step III, while the utilization of unitary metrics for the most effective energy-efficient and RES interventions led to the quantification of the triggered impacts in Step IV.

6.2 Step I: Assessment and selection of the most effective energy efficient and RES interventions

Four different combinations of energy efficiency and RES interventions were examined for both the multi-family and the single-family buildings as depicted in Figure 43.

More specifically, the following renovation options were modelled and analysed:

- Option 1: Change of windows and doors, and installation of new heat pump for space heating, DHW and cooling
- Option 2: Only the building envelope is improved by insulating the walls and roof and changing the old wooden windows and doors
- Option 3: all options for the building envelope and technical systems are combined.
- Option 4: Change of windows and doors, and installation of new heat pump for space heating, DHW and cooling and PV generation.

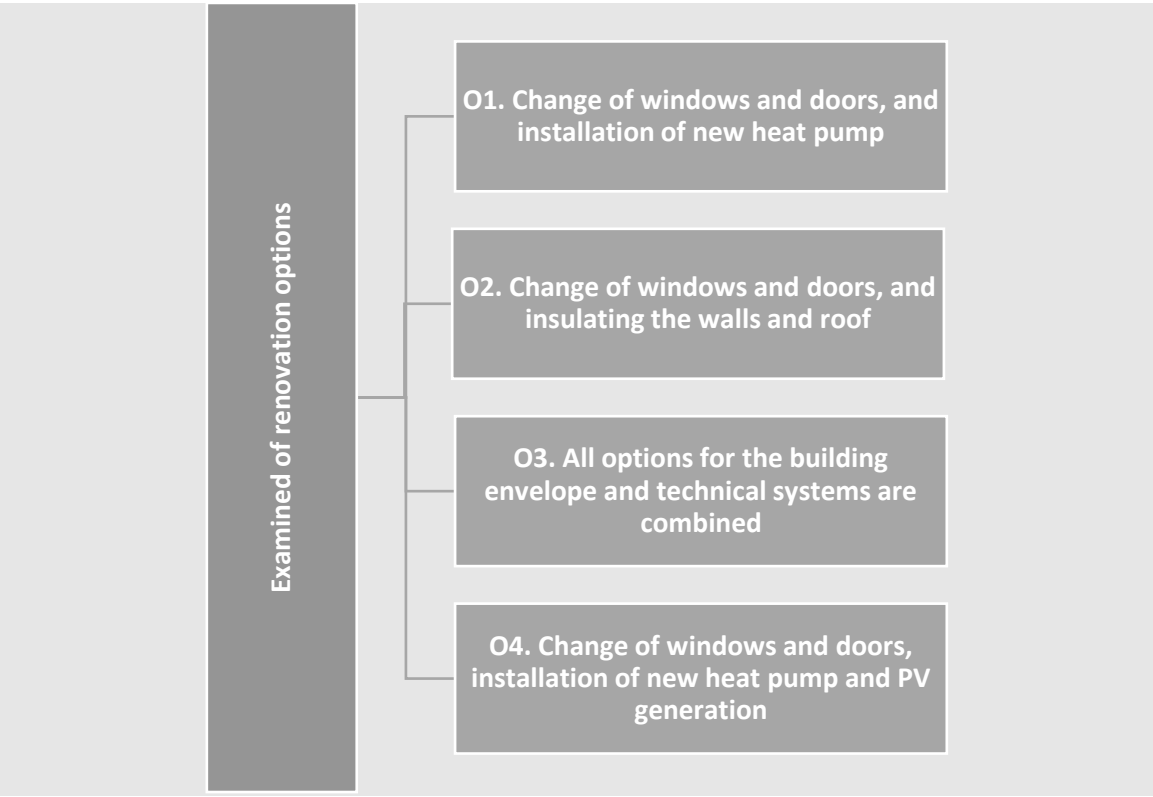


Figure 43. Examined combinations of energy efficient and RES interventions.

The analysis led to the following results as presented in Table 15 concerning the calculation of two different indicators for their comparative analysis.

Option 4, i.e. replacement of windows and doors, installation of a new heat pump and PV generation, presents the best diversity of options (energy efficiency and RES) and good performance on the examined indicators, and therefore it was selected for the Roadmap II.

Table 15. Results of the examined energy efficiency and RES interventions.

Cost effectiveness based on the final energy savings (€/kWh)	Single-family buildings
O1. Change of windows and doors, and installation of new heat pump	0.837
O2. Change of windows and doors, and insulating the walls and roof	2.657
O3. All options for the building envelope and technical systems are combined	2.408
O4. Change of windows and doors, installation of new heat pump and PV generation	0.841
Cost effectiveness based on the CO_2 emission reduction (€/kg CO_2)	**Single-family buildings**
O1. Change of windows and doors, and installation of new heat pump	5.540
O2. Change of windows and doors, and insulating the walls and roof	17.597
O3. All options for the building envelope and technical systems are combined	15.945
O4. Change of windows and doors, installation of new heat pump and PV generation	5.568

6.3 Step II: Identification of the main pathway for the developed scenario

The main aim of the building renovation roadmap is to accelerate the deep renovation of residential buildings to ensure the effective alleviation of energy poverty. The combination of energy efficiency and RES interventions is an essential approach to facilitate the deep renovation of the buildings that are dwelled by energy-poor households.

Therefore, all the buildings, which have been constructed before 2005, should be renovated starting with the worst-performing buildings (the oldest ones) and continuing with the remaining.

The unitary results of the selected combination of energy-efficient interventions are presented in Table 16. The primary energy savings represent 85.9% of savings, clearly exceeding the typical values to consider it as a deep renovation.

Table 16. Estimated unitary results for the selected energy efficiency and RES interventions.

Roadmap II	Single-family buildings
Final energy savings (kWh/year)	7841
Primary energy savings (kWh/year)	19604
CO_2 emission reduction (kg CO_2/year)	1184
Investment cost (€)	6593
Cost savings (€/year)	2169

6.4 Step III: Determination of the renovated buildings totally

The number of renovated buildings was estimated taking into consideration that 17.5% of the households are affected by the phenomenon of energy poverty as resulted in the presented analysis in Chapter 2.

The buildings in the Municipality of Coimbra were taken into account for the determination of the targeted buildings, being then selected 17.5% of the buildings (corresponding to the buildings associated with energy poverty).

Information about the number of the newly and cumulative buildings is provided in Table 17 and Table 18, respectively including information about the trajectory and the timeline.

Table 17. Number of newly renovated buildings.

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy poor households - Single family houses (SFH)	1341	1341	1341	1341	1341

Table 18. Number of cumulatively renovated buildings.

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy poor households - Single family houses (SFH)	1341	2682	4023	5364	6705

The estimation of the triggered impacts by the energy efficiency and RES interventions was implemented with the utilization of unitary metrics as a result of the modelling activity, which was carried out for each examined measure within the framework of Step I (Table 16).

6.5 Step V: Calculation of the triggered impacts for all renovated buildings

The expected cumulative final energy savings, primary energy savings and CO_2 emission reduction are presented in

Table 19, Table 20, and Table 21, respectively. The calculation of the delivered impacts was performed using the unitary metrics in Table 16 and the cumulative number of renovated buildings.

Table 19. Resulted cumulative final energy savings (GWh).

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy poor households - Single family houses (SFH)	10.51	21.03	31.54	42.06	52.57

Table 20. Resulted cumulative primary energy savings (GWh)

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy poor households - Single family houses (SFH)	26.29	52.58	78.87	105.16	131.44

Table 21. Resulted cumulative CO2 reduction (ktn CO_2).

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy poor households - Single family houses (SFH)	1.59	3.18	4.76	6.35	7.94

The expected employment impacts were calculated (Table 22) using the respective result of the study conducted by Cambridge Econometrics in 2022 (creation of 15.5 person-years/million EUR invested in building renovations). It should be noted that the calculation was performed based on the number of newly renovated buildings.

Table 22. Resulted employment impacts (person-years).

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy poor households - Single family houses (SFH)	137.0	137.0	137.0	137.0	137.0

Finally, the expected cumulative multiple benefits were calculated (Table 23) assuming that are equal to 0.039 €/kWh.

Table 23. Resulted cumulative multiple benefits (million €).

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy poor households - Single family houses (SFH)	0.64	1.27	1.91	2.55	3.18

7 Policies and measures

The specified renovation targets will be achieved with the design and implementation of several policies and measures. These policies and measures are in full alignment with the provisions of the NECP, as defined in the Long-term strategy for mitigating EP in Portugal, as part of the Portuguese strategy to ensure that the process of decarbonisation and energy transition takes place in a fair, cohesive and inclusive manner and thus the steps taken over the next decade must not accentuate energy poverty, rather, solutions must be found to mitigate this problem. Even though the investment in improving the energy performance of buildings has been overall increasing in Portugal, in conjunction with various examples of good instrument practices and consequent cost-effective energy savings that are in place, there are still limited financial mechanisms or products for this purpose that are accessible to consumers in general. In this context, it is particularly relevant to channel public support and funding for tackling the EP problem. In fact, at a time when there are widespread market failures to respond to this issue, public support policy becomes critical and must be aligned with the objectives of the energy transition and decarbonisation, as well as the country's economic recovery, giving positive and clear signals to consumers and boosting new investments and interventions. At the same time and in a complementary way, regulatory and fiscal policies also play an important role in the fight against energy poverty, influencing changes in behaviour and the adoption of new ones.

Situations of energy poverty are to be mitigated through diverse measures including urban rehabilitation and promoting energy efficiency and renewable energy sources. More specific information about the foreseen policies and measures is provided in the following tables.

1) Promoting the energy and environmental sustainability of housing

Name of policy or measure	M1.1: Increase Energy Performance of buildings
Short description	Support for energy efficiency actions - support actions and develop support and incentive mechanisms (including non-reimbursable support) that promote decarbonization and housing energy efficiency (owners and tenants), namely in the renovation and rehabilitation of buildings, by adopting sustainable construction solutions with special focus on insulation, leading to an increase in the energy performance of buildings and the improvement of living conditions and thermal comfort, in the replacement and/or adoption of

Name of policy or measure	M1.1: Increase Energy Performance of buildings
	energy-efficient equipment and systems, promoting consumption electrification, and in the implementation of renewable energy production and storage systems.
Quantified objective	Total area of buildings renovated Percentage of buildings renovated Number of hours of discomfort Primary energy consumption
Type of policy or measure	Economic incentives, investment support, subsidies, tax/fiscal incentives
Planned budget and funding sources	Public and private funds PRR|FA Banking sector|OE|
Entities responsible for implementing the policy	Ministry of Environment and Energy Ministry of Economy and Finance
Number of affected households	6705 single-family houses (SFH)
Expected impact in relation to the specified targets	Contribution to the expected impacts
Status of implementation	Mostly ongoing
Date of entry into force	2020
Implementation period	2024-2050

Name of policy or measure	M1.2: Decarbonizing household energy consumption
Short description	Promote and support the electrification of household energy consumption, in an efficient and sustained manner, by means of incentive mechanisms for the acquisition and/or substitution of equipment, promoting a transfer from fossil-based household consumption (e.g. LPG) to electricity. Promote and support projects on a local scale - "Sustainable Neighbourhoods", "Sustainable Villages" - with the aim of creating local dynamics with the involvement of communities and local agents, through intervention in housing and dissemination of information and awareness actions, enabling economies of scale and concentrating support and funding to support more families.
Quantified objective	Percentage of electricity consumption met by local renewable generation. Installed power in local renewable electricity production systems. Fraction of consumption for heating and cooling met by local renewable production Power installed in local renewable heating/cooling systems

	Fraction of electricity consumption in total energy consumption
Type of policy or measure	Non reimbursable funding, tax incentive, economic incentives, subsidies, regulation, building capacity, VAT reduction
Planned budget and funding sources	Public and private funds PRR|FA Banking sector|OE|
Entities responsible for implementing the policy	Ministry of Environment and Energy Ministry of Economy and Finance
Number of affected households	6705 single-family houses (SFH)
Expected impact in relation to the specified targets	Contribution to the expected impacts
Status of implementation	Ongoing; upcoming, ...
Date of entry into force	2020
Implementation period	2024-2050

2) Promoting universal access to essential energy services

Name of policy or measure	**M2.1: Reduce the number of households struggling to pay for essential energy services /Burden reduction**
Short description	Support the price and burden reduction, promoting programs, actions and mechanisms that allow for energy burden reduction, as is the case of the Social Tariff for Energy, and energy services for domestic consumers, both through awareness-raising actions that stimulate correct energy use and management, and through support so that the price of energy is not a factor of exclusion in access to these services, regardless of the economic, social or geographical situation of consumers, while serving the purpose of ensuring universal access to quality services at affordable prices. Inclusive energy transition - support investment to be carried out by renewable energy communities, including and involving vulnerable consumers in situations of energy poverty, aiming to reduce the burden of energy bills, promoting increased self-consumption and energy sharing.
Quantified objective	Average reduction of the energy bill, nº of households with self-consumption systems, nº of households integrated in renewable energy communities
Type of policy or measure	Regulation, financial support/tariff reduction, non-reimbursable funding

Name of policy or measure	M2.1: Reduce the number of households struggling to pay for essential energy services /Burden reduction
Planned budget and funding sources	Market operators (electricity and gas), OE, PRR, FA
Entities responsible for implementing the policy	Ministry of Environment and Energy Ministry of Economy and Finance ERSE/ energy suppliers
Number of affected households	6705 single-family houses (SFH)
Expected impact in relation to the specified targets	Contribution to the expected impacts
Status of implementation	Existing
Date of entry into force	2011
Implementation period	2019-2050

Name of policy or measure	M2.2: Ensure the protection of vulnerable consumers facing energy poverty
Short description	Protect consumers whenever they are unable to meet their energy costs or in their relationship with market operators, promoting programs, actions and mechanisms that reinforce the access conditions to essential energy services safeguarding the well-being and health of households in a situation of energy poverty, either through the development of mechanisms that signal and assist vulnerable consumers to combat the energy poverty in which they are inserted and to meet the payment of the bill, in extreme and adverse weather situations that impact on energy consumption, or by promoting the development of self-consumption, individual, collective, or by creating renewable energy communities, stimulating the energy sharing.
Quantified objective	Nº of energy disconnections avoided
Type of policy or measure	Regulatory / Social protection
Planned budget and funding sources	n.a.
Entities responsible for implementing the policy	Ministry of Environment and Energy Ministry of Social Affairs
Number of affected households	6705 single-family houses (SFH)
Expected impact in relation to the specified targets	n.a
Status of implementation	Existing
Date of entry into force	2019
Implementation period	--

3) Promoting integrated territorial action

Name of policy or measure	M3.1 Strengthen the action of local structures in supporting citizens
Short description	Local actions - promote and support projects on a local scale - "Sustainable Neighbourhoods", "Sustainable Villages" - with the aim of creating local dynamics with the involvement of communities and local agents, through intervention in housing and dissemination of information and awareness actions, enabling economies of scale and concentrating support and funding to support more families. Promoting an integrated network of citizen spaces Energy Promote the integration of the fight against energy poverty into local public policies Facilitate the development of municipal renewable energy communities
Quantified objective	Number of citizenship spaces Number of public policy instruments Number of renewable energy communities
Type of policy or measure	Regulatory, Capacity building
Planned budget and funding sources	Climate Fund (FA)
Entities responsible for implementing the policy	Municipalities-local authorities Social Sector Entities Energy agencies
Number of affected households	6705 single-family houses (SFH)
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by the measures
Status of implementation	Under development
Date of entry into force	-
Implementation period	2025-2050

Name of policy or measure	M3.2: strengthening the supply of public housing with high energy performance
Short description	Social Housing - articulate actions for energy rehabilitation in social housing buildings, focusing on energy efficiency in order to increase the energy and environmental performance of housing, and promoting the fight against energy poverty, improving the living conditions and comfort. Promote new NZEB construction.
Quantified objective	Renovated building area Percentage of renovated buildings Number of hours of discomfort

Name of policy or measure	M3.2: strengthening the supply of public housing with high energy performance
	Area of new buildings
Type of policy or measure	Investment support
Planned budget and funding sources	Public Funds |PRR
Entities responsible for implementing the policy	Ministry of Housing Central and Local government
Number of affected households	6705 single-family houses (SFH)
Expected impact in relation to the specified targets	Contribution to the expected impacts
Status of implementation	Ongoing
Date of entry into force	2022
Implementation period	2020-2030

4) Promoting knowledge and integrated action

Name of policy or measure	M4.1: Increase capacity to identify vulnerable people
Short description	The strategic objective of this measure is to increase the capacity to identify households in situations of energy poverty. It aims to obtain a diagnosis and characterisation of the problem, develop monitoring indicators, and monitoring strategies and establish medium and long-term energy poverty reduction objectives at national, regional and local levels.
Quantified objective	Number of indicators developed Number of indicators with defined calculation methods Number of energy poverty initiatives identified number of support structures
Type of policy or measure	Information
Planned budget and funding sources	Not available
Entities responsible for implementing the policy	DGEG/ADENE Statistics office
Affected roadmaps	Not applicable
Number of affected households	Not applicable
Expected impact in relation to the specified targets	--
Status of implementation	To start
Date of entry into force	2025
Implementation period	2025-2050

Name of policy or measure	M4.2: Increase energy literacy
Short description	It aims to increase the overall energy literacy of private consumers, from children and young people to consumers in situations of severe energy poverty or at risk of exclusion, and consumers in general. The main actions are: 1) integration with curricular matrices (basic, secondary and vocational education); 2) energising the school community; 3) promotion of training activities dedicated to specific target audiences; 4) strengthening the content, scope and integration of platforms; 5) developing information and awareness-raising materials and campaigns.
Quantified objective	Increase levels of literacy of the various target groups
Type of policy or measure	Information
Planned budget and funding sources	Not available
Entities responsible for implementing the policy	Energy Agencies, national and regional; Education
Number of affected households	6705 single-family houses (SFH)
Expected impact in relation to the specified targets	
Status of implementation	Planned
Date of entry into force	2024-2025
Implementation period	2030-2040-2050

Name of policy or measure	M4.3: Stimulate research and innovation
Short description	Social Innovation - create and support a social innovation ecosystem to combat energy poverty, promoting and supporting innovative projects and new technologies to combat energy poverty. The projects should adopt disruptive, enabling, diagnostic and operational solutions, in order to create dynamics and explore new approaches and models to combat energy poverty with the involvement of various partners (technological, qualified experts, business, universities and research centres, municipalities and local actors).
Quantified objective	Number of projects and initiatives Number of financing instruments Number of entities involved
Type of policy or measure	Information
Planned budget and funding sources	Not available
Entities responsible for implementing the policy	R&I&D Institutions, Universities, think tanks, NGOs, ESCOs, National authorities, ...

Name of policy or measure	M4.3: Stimulate research and innovation
Number of affected households	6705 single-family houses (SFH)
Expected impact in relation to the specified targets	-
Status of implementation	To be defined
Date of entry into force	To be defined
Implementation period	2030-2050

Name of policy or measure	M4.4: Stimulate training of professionals
Short description	Promoting professional training for specialisation and the acquisition of new skills, offering: - short and medium-term training courses for the energy rehabilitation of buildings; - short and medium-term training courses in the design and installation of renewable energy systems; - short and medium-term training courses for the design and installation of heating and cooling systems.
Quantified objective	Number of people certified
Type of policy or measure	Capacity building
Planned budget and funding sources	Public and private (IEFP, ADENE, APREN)
Entities responsible for implementing the policy	IEFP, ADENE, APREN
Number of affected households	--
Expected impact in relation to the specified targets	+30 000 (2030); +50 000 (2040); +70 000(2050) certified people
Status of implementation	Under development
Date of entry into force	2025
Implementation period	2025-2050

In a nutshell, transitioning to a carbon-neutral society in a fair and inclusive way, combating energy poverty and including all citizens, implies mobilising investment and mechanisms, while promoting greater economic dynamics and the creation of skilled jobs. Among the challenges preventing investment in improving the energy performance of buildings include the financing component, associated with high initial investment costs, particularly for the most vulnerable and energy-poor households, the relatively long amortisation periods and credit risks, or their perception, associated with energy efficiency investments.

Portugal is strongly committed to tackling energy poverty by addressing its multidimensional aspects and involving the various key players, redirecting support and financial flows to combat energy poverty, and aligning the objectives of decarbonisation and transition:

- increase housing energy performance, promoting programs, actions and support mechanisms of a structural nature to combat situations of energy poverty, which includes targeted interventions to make investments in energy efficiency and rehabilitation of buildings, incentives for changes in consumption patterns and actions aimed at the integration of renewable energy;
- mobilize the financial institutions to create the appropriate mechanisms that allow for the creation of a lending framework that enables widespread and simplified access to sources of financing for energy efficiency actions in housing, including, for example, surcharges and subsidies for the most vulnerable households, helping to increase the degree of accessibility and equity in access to financing mechanisms These actions will be developed with the various actors, national and local, including various regional and local bodies in the various aspects, to better adapt to the reality and promote proximity to consumers in situations of energy poverty;
- Promote the development of training and information campaigns to raise awareness and disseminate best practices for energy efficiency aiming to stimulate behavioural change when using energy aiming to obtain savings with the energy bill, comfort and environmental gains. Advisory and assistance structures should be created and strengthened for this purpose and for the dissemination of available incentive systems in order to increase housing energy efficiency. Promote the development of programs and actions in schools, among young people - agents of change and multipliers of information in their households - where the problems of energy efficiency, energy poverty and the importance of individual and collective commitment in changing behaviours in energy use will be addressed, also with a view to effectively tackling climate change.

8 Investment needs

The investment needs required for the implementation of the building renovation roadmaps are presented in Table 24 and Table 25 both for the case of the new and cumulative ones.

Table 24. Required new investments (million €).

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households – Single-family houses (SFH)	8.84	8.84	8.84	8.84	8.84

Table 25. Required cumulative investments (million €).

Type of households – Roadmap II	2024-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households - Single-family houses (SFH)	8.84	17.68	26.52	35.36	44.21

The allocation of the total investments to the different energy efficiency and RES interventions within Roadmap II is displayed in Figure 44*Figure 44. Allocation of the total investments to the different energy efficiency and RES interventions (Roadmap II).*

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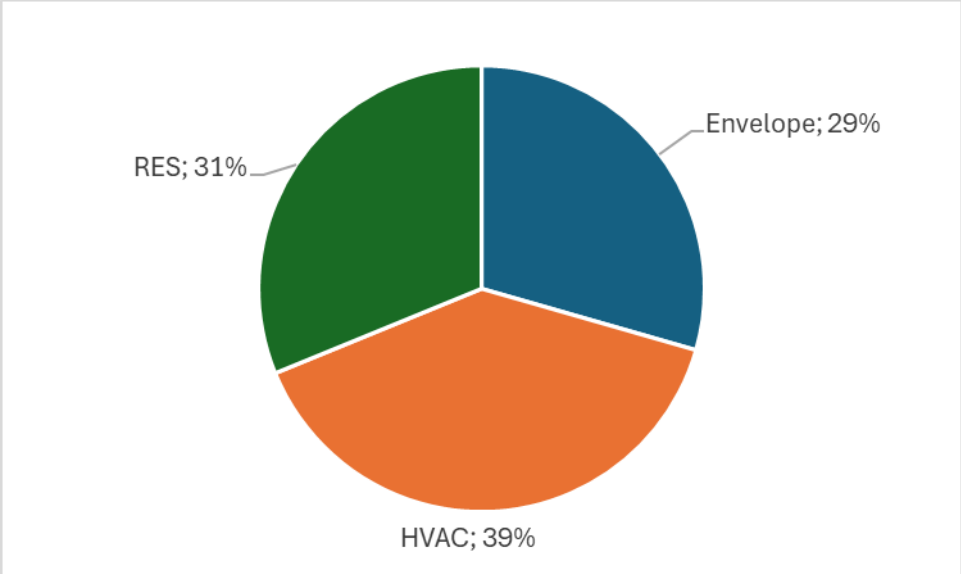

Figure 44. Allocation of the total investments to the different energy efficiency and RES interventions (Roadmap II).

The allocation of the total investments to public and private investments is presented in Table 26. The allocation was performed assuming that the energy poor households can be divided into three different categories with different capabilities to contribute with their own funds to the planned investments. More specifically, the following assumptions were made:

- Category I: 20% of the targeted energy poor households will receive public aid equal to 50% of the foreseen investment cost.
- Category II: 30% of the targeted energy poor households will receive public aid equal to 75% of the foreseen investment cost.
- Category III: 50% of the targeted households will receive public aid equal to 90% of the foreseen investment cost.

Table 26. Allocation of the total investments to public and private investments (million €).

Roadmap	Energy poor households	Share	Public funds	Private funds	Total
II SFH	**Category I**	20%	4.42	4.42	8.84
	Category II	30%	9.95	3.32	13.26
	Category III	50%	19.89	2.21	22.10
	Total	**100%**	**34.26**	**9.95**	**44.21**

It should be noted that the analysis of the different types of financing instruments has been indicated within the previous chapter for each policy and measure separately.

9 Renovations triggered by REVERTER

REVERTER is expected to contribute to the renovation of social housing in the Municipality of Coimbra by the end of the project and within a period of five years after its completion (2025-2030). The renovations will be triggered by the establishment and operation of the physical and digital one-stop shops, visits to homes of energy poor households by REVERTER Ambassadors and local facilitators who will inform them about energy renovation issues and awareness-raising and training activities in order to reinforce the existing level of knowledge of energy poor households. According to the initial estimates described in Section 3 "Impact calculation table" of D1.4 "Extract of the project data from the LIFE KPI webtool", approximately 1,800 households in Coimbra region will be reached through information campaigns, home visits and social engagement events. Of these households, it is estimated that around 272 will visit the physical and digital one-stop shops and around 15%, i.e. 41 households will express interest in upgrading their home in the next 5 years, and more specifically, 32 apartments (i.e., renovation of four buildings with eight households) and 9 single-family houses.

The contribution of REVERTER regarding social SFBs (Roadmap II) is summarised in Table 27. Since the buildings to be renovated are social housing owned by the Municipality, the initial investment will be covered 100% by public funds.

Table 27. Contribution of the REVERTER project to the implementation of the specific roadmap for the renovation of social SFBs in the period 2025-2030.

Impacts Roadmap II	Energy poor households–Social single-family buildings-(SFH)
Number of newly renovated buildings	9
Resulted cumulative final energy savings (GWh)	0.071
Resulted cumulative primary energy savings (GWh)	0.176
Resulted cumulative CO_2 reduction (ktn CO_2)	0.0107
Resulted employment impacts (person-years)	0.9
Resulted cumulative multiple benefits (million €)	0.0043
Required new investments (million €)	0.059

10 Monitoring and evaluation framework

A holistic monitoring and evaluation framework will be established in order to monitor and assess the implementation of the building renovation roadmap and the realization of the planned investments.

The proposed monitoring and evaluation mechanism consists of seven different sub-mechanisms, which are related either directly or indirectly (coordination, monitoring, measurement, data collection, control and verification, reporting and evaluation mechanisms) as depicted in Figure 45.

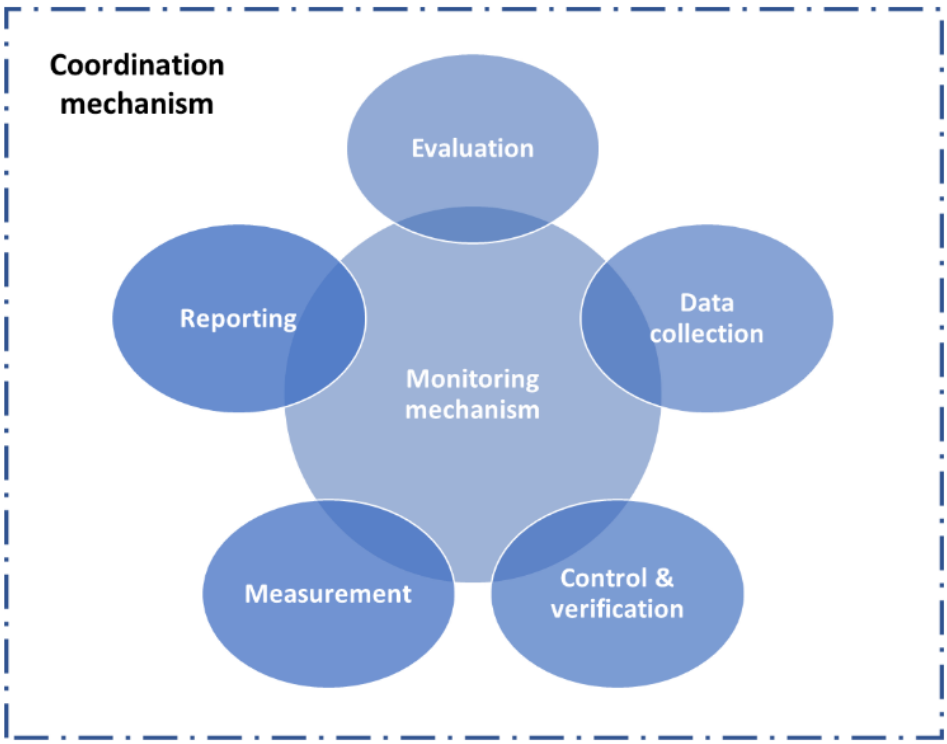

Figure 45. Overview of the sub-mechanisms within the established monitoring and evaluation framework.

The Ministry of Environment and Energy should be appointed as the responsible authority for the proposed monitoring and evaluation mechanism.

The role of the coordination sub-mechanism is considered the most important one, as it will facilitate the efficient cooperation and implementation of the remaining six sub-mechanisms, ensure the coherence of the monitoring and evaluation mechanism with the energy efficiency and RES investments and create the appropriate conditions of commitment and trust among the involved authorities and bodies.

The coordination sub-mechanism should be developed in order to facilitate the vertical and horizontal coordination of the planned investments. Vertical coordination ensures effective communication and administration among the different governmental levels, namely national, regional and local levels for designing and implementing energy efficiency policies and/or concrete measures. Horizontal coordination enables the effective communication and administration of the different energy efficiency measures, and schemes of programmes at the same level.

The monitoring sub-mechanism aims at the continuous monitoring of the implemented energy efficiency and RES investments and the delivered impacts to initiate the appropriate measures in the case that the progress is not assessed as satisfactory and according to the roadmap. The monitoring sub-mechanism should be based on the combination of top-down and bottom-up monitoring, which is recommended to be implemented through the development and operation of an IT platform. The top-down monitoring will be carried out with the monitoring of specific statistical data at national and sectoral levels about the evolution both of the final energy consumption and the energy poverty. Simultaneously, the framework for bottom-up monitoring should be established for collecting information on the number of renovated buildings. It should be pinpointed that the introduction of bottom-up monitoring affects the implementation of the measurement, control and verification, and data collection procedures.

The development of the measurement sub-mechanism should be implemented taking into consideration the provisions of Annex V of the Directive 2023/1791/EE. Specifically, the calculation of the achieved energy savings should be conducted through the utilization of five different calculation methods (deemed savings, metered savings, scaled savings, surveyed savings and savings of people affected by energy poverty, vulnerable customers, people in low-income households and, where applicable, people living in social housing) based on engineering estimates using standardized occupancy and thermal comfort conditions or parameters.

The data collection sub-mechanism should consist of six different steps. Initially, the energy efficiency and RES investment should be selected for monitoring and assessment in Step 1. Then, the various types of data, that should be collected, have to be identified within the context of Step 2. The selection of the required data must be done along with the measurement method either top-down or bottom-up, which has been developed for each energy efficiency and RES investment separately.

After the identification of the data, the available data sources should be mapped in Step 3, while the responsible body and the respective procedure for the collection of the identified data must be specified. It is crucial to define with clarity what type of data should be collected by each involved body, how these data will be analysed and by whom. Step 4 foresees the collection of the required data from the identified data sources.

Moreover, a specialized procedure should be implemented to control and validate the collected data following specific criteria, such as their accuracy, robustness and coherence within the control and verification sub-mechanism in Step 5. Indicative methods in order to validate the compliance with these criteria include the evaluation of the closeness between the estimated results and the true values, the comparison of the obtained results with the respective ones over time and from other spatial domains and the comparison of the estimated results with the corresponding ones from different sources or methods. Finally, a combination of verification and control techniques (plausibility check, desktop checks, on-site checks on a specific sample and extrapolation to the total investments) to the collected data should be conducted in Step 6 so as to ensure the quality of the collected data as displayed in Figure 46.

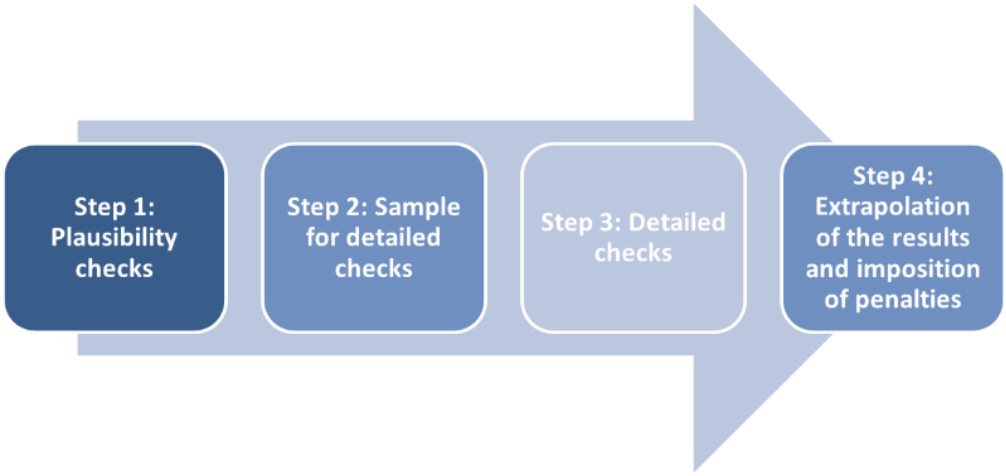

Figure 46. Steps for the conduction of the required control and verification activities.

The reporting of the implemented energy efficiency and RES investments should be performed on an annual basis within the framework of the reporting sub-mechanism. The actual budget and the quantified impacts should be reported for each energy efficiency and RES investment separately. The calculation of the delivered energy savings will be performed in accordance with the selected measurement protocol. Moreover, additional quantitative information about the implementation of energy efficiency and RES investments should also be provided. It should be noted that the quantitative information must be linked with the developed bottom-up equations within the bottom-up monitoring. The required data will be collected by the implementation both of the foreseen top-down and bottom-up monitoring procedures.

A template will be prepared for the collection of the required data including the establishment of the appropriate data collection procedures. Furthermore, the potential deviations for monitored indicators will be estimated taking into consideration the expected performance in the examined year according to the provisions of the building renovation roadmap compared to the actual ones.

Finally, all the implemented energy efficiency and RES investments should be evaluated within the framework of the assessment sub-mechanism through the conduction of cost-effectiveness and/or cost-benefit analyses. The analysis aims to assess the effectiveness of the implemented policies and measures to decide their continuation or improvement or replacement with new more effective to achieve the specified renovation targets.

The assessment of the implemented policies and measures can be performed at least using the following indicators:

- Investment cost/Final energy savings (million €/GWh)
- Investment cost/Primary energy savings (million €/GWh)
- Investment cost/CO_2 emission reduction (million €/ktn CO_2)
- Public funds/Final energy savings (million €/GWh)
- Public funds/Primary energy savings (million €/GWh)
- Public funds/CO_2 emission reduction (million €/ktn CO_2)
- Private funds/Final energy savings (million €/GWh)
- Private funds/Primary energy savings (million €/GWh)

- Private funds/CO_2 emission reduction (million €/ktn CO_2)

Last but not least, the potential adjustment of the building renovation roadmap should be initiated in the case of deviations from the planned renovation rate and the foreseen investments. A threshold should be specified for potential deviations (such as indicatively 10% deviation) in order to activate the adjustment of the building renovation roadmap taking into account the concluded outcomes from the assessment of the already implemented policies and measures and identifying an updated pathway for the attainment of the renovation targets.