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Rural Energy Efficiency Roadmap

Arzila-Coimbra

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About RENOVERTY

RENOVERTY will foster energy efficiency building upgrades in the Central and Eastern Europe (CEE), South-eastern Europe (SEE) countries, as well as Southern European countries (SE), by setting the methodological and practical framework to build renovation roadmaps of vulnerable rural districts in a financially viable and socially just manner.

Specifically, the project aims to deliver tools and resources to support local and regional actors to build and execute operational single or multi-household roadmaps for rural areas. A scalable model will also be created to ensure the wide geographical replicability and implementation of the roadmaps by different actors at the EU level. Strategically, the project will contribute to minimising logistical, financial, administrative, and legal burdens caused by a complex and multi-stakeholder home renovation process. Additionally, RENOVERTY will ensure that building retrofits consider the social dimension by incorporating security, comfort, and improved accessibility in the roadmaps to further improve the quality of life of vulnerable populations.

Over the project's three years, seven pilots located in Sveta Nedelja (Croatia), Tartu (Estonia), Bükk-Mak & Somló-Marcalmente-Bakonyalja Leader (Hungary), Zasavje (Slovenia), Parma (Italy), Coimbra Region (Portugal), and Osona (Spain) will implement the roadmaps, while wider integration of rural and peri-urban development is foreseen in the long run.

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CAP	Common Agricultural Policy
CCDRC	Comissão de Coordenação e Desenvolvimento da Região Centro
CIM	Comunidade Intermunicipal da Região de Coimbra
CO_2	Carbon dioxide
CLLD	Community-based Local Development
DREEM	Dynamic high-Resolution dE-mand-sidE Management
EED	Energy Efficiency Directive
EEM	Energy Efficiency Measure
EIB	European Investment Bank
EPC	Energy Performance Certificate
EAFRD	European Agricultural Fund for Rural Development
EPBD	Energy Performance of Buildings Directive
HVAC	Heating, Ventilation Air Conditioning
LAG	Local Action Group
LCSE	Levelised Cost of Saved Energy
LDS	Local Development Strategies
LTRS	Long Term Renovation Strategy
MFB	Multi Family Buildings
NPV	Net Present Value
PP	Payback Period
PQ	Perito Qualificado/Qualified Expert
IPSS	Private Social Solidarity Institutions
RE	Renewable energy
REC	Renewable Energy Communities
SECAPs	Sustainable Energy and Climate Action Plans
SFH	Single-family house
SCE	Sistema de Certificação Energética
TIS	Técnico de Inspeção de Sistemas técnicos
TGE	Técnico de Gestão de Energia
TRM	Técnico Responsável pela instalação e Manutenção
VMCs	Central Mechanical Ventilation

EXECUTIVE SUMMARY

This document serves as a roadmap (Rural Energy Efficiency Roadmap – REER) to help citizens navigate the home renovation process. It is developed under the RENOVERTY project (Home Renovation Roadmaps to Address Energy Poverty in Vulnerable Rural Districts), a project co-funded by the European Commission under the LIFE programme, that aims to produce energy efficiency roadmaps for specific vulnerable districts to increase the energy efficiency status of buildings in rural areas and alleviate energy poverty by increasing quality of life and reducing health problems of vulnerable households. RENOVERTY will also train and provide various tools to increase the knowledge and capacity building of all the actors involved in the value chain, so that they could know how to successfully approach each phase of renovation and have the means to realise the benefits of energy efficiency improvements.

The primary goal of the REER is to support energy renovations for rural households affected by energy poverty. It serves as a valuable resource for key stakeholders, including:

1) households experiencing energy poverty.

2) local actors who can assist households in the renovation process, such as social workers, humanitarian organizations, healthcare workers, and LAGs.

3) local, regional and national authorities responsible for developing and implementing policies and measures to mitigate energy poverty.

The first section of this document contextualizes the problem of rural energy poverty, while the second section of the REER is mainly directed at households, providing solutions to improve their comfort levels and lower their energy bills through the implementation of energy renovations.

This REER is the result of a consultation process that puts the local agents at its core and, most importantly, the concerns of people facing energy poverty. Furthermore, it has been supported by a number of local, regional and national actors through joint workshops and consultations.

1 Contextualization

This roadmap identifies opportunities for energy renovations, focusing on citizens experiencing energy poverty living in single-family houses in rural areas. By offering tailor made solutions that align with the unique needs of these specific local communities, regional and municipal authorities in the rural and peri urban region of Coimbra can scale up efforts to tackle one of the biggest social challenges of the upcoming decade – ensuring sustainable, energy-efficient homes for all.

1.1 The multidimensional aspects of energy poverty in Portugal

Energy poverty in Portugal is a multifaceted issue influenced by various factors, including income levels, housing conditions and access to energy services.
Recent studies: "*Energy poverty in Portugal: Combining vulnerability mapping with household interviews*" (energy-poverty.ec.europa.eu), *"Assessing Energy Poverty in Portugal Through the Lens of a Social Survey"* (https://doi.org/10.3390/en17164087) provide an in-depth analysis of the multidimensional nature of energy poverty in the country, highlight the variability of vulnerability throughout Portugal and allow for a deeper comprehension of the factors that impact energy poverty. Many households consider it normal to experience discomfort due to inadequate heating or cooling, which can obscure the recognition of energy poverty's impact on well-being and health. These resources offer valuable insights into the complex and interconnected factors contributing to energy poverty in Portugal.
Therefore, any action tackling energy poverty in the country needs to address the multidimensional aspects, where capacity building and education play an important role. The COVID-19 pandemic has intensified inequalities and has helped highlight that energy poverty extends beyond the usual definition, resulting in a complexity of interrelated poverties: energy poverty, digital poverty, education poverty, food poverty, health poverty, etc. While there are some measures to reduce the energy bills of vulnerable households at the national level, like the social tariff, it is widely recognised there is a need for a structured strategy to reduce energy costs based on robust and consolidated information and financial support to help lower-income families to improve their quality of life, mitigating energy poverty. To further exacerbate the prevalence of energy poverty in Portugal's rural communities, rural desertification is also increasing, mainly because the Central Government has been implementing public policies that oddly favours the exodus to large cities, attracted by the greater economic dynamism and social development and emptying the countryside.

1.2 Relevant considerations for the rural road map

For years, there has been a long public debate in Portugal about the need for territorial cohesion and more equality in the distribution of financial resources to avoid specific vulnerabilities and fragilities in rural areas. Yet, decision-making in Portugal remains highly centralized in the capital city of Lisbon, where government institutions shape national policies. However, this centralization can create a disconnect between decision-makers and the realities faced by communities across the country. As a result, governance is often influenced by strategic agendas that may not fully reflect the diverse needs and priorities of all Portuguese regions. Therefore, this RENOVERTY roadmap is very timely, as it contributes to decreasing inequalities and targets inhabitants who are most in need of support. The main added value of this project, while addressing home renovations in the most vulnerable areas, is to raise awareness and respect for the rural environment amongst policy and decision-makers, thus contributing to keeping and promoting locally embedded knowledge, cultural identity, and nature preservation (ensuring that the country's inner rural areas are not left to the fires, for example, which is a well-known and increasing problem that rural regions in Portugal face).

According to the State of the Energy Union report, recently published by the EU executive in Brussels, Portugal, and Spain registered the highest percentage of energy poverty in the EU in 2023, showing that 20,8% of people were unable to keep their homes adequately heated. The numbers in Portugal are frightening. There are at least 660,000 people in severe energy poverty which means that they belong to the group of inhabitants whose energy expenditure represents over 10% of their total income and who are exposed to 'situations of monetary or economic poverty' with the impossibility of keeping their homes in comfortable thermal conditions. Aware of this major problem, by 2030, the National Strategy to Combat Energy Poverty wants to reduce the percentage of Portuguese citizens without the funds to heat their homes in winter to 10%. This is quite a challenging target if the government does not release significant incentives for the renovation of buildings, as the existing building stock is very inefficient. For the time being, existing financing mechanisms aiming to reduce consumption or the transition towards cleaner energy, at the household level, are scarce and are not designed to promote building renovations of vulnerable households, but to help pay their energy bills temporarily (social tariff and energy efficiency vouchers, for example). This support is useful, but if not accompanied by additional, more structural support measures it provides the wrong incentive and does not solve the root of the problem or address the main principle: *energy efficiency first*.

In a recent event (mid-January 2025), the ministry stated that existing support programmes did not have a significant impact because the mechanism was complicated, the application processes were highly bureaucratic, unclear, eligible for All citizens, independently of economic status, and promoting free ridership,. Therefore, the

government has recently announced some changes in the existing support programs for energy efficiency and promised additional support schemes. According to the ministry, a new energy efficiency support programme, specifically aiming at households experiencing energy poverty, should be launched in the first semester of 2025.

1.3 Upcoming financing mechanisms: policies, programs and initiatives

The Energy and Environmental Ministry is preparing new initiatives to combat energy poverty, which will consist of support for energy efficiency. The old Support Programme for More Sustainable Buildings will be discontinued, so the focus will now be on the most vulnerable families. ***'We are preparing a new initiative to combat energy poverty**,'* said Maria da Graça Carvalho in November 2024, when presenting the Energy and Environment measures included in the proposed State Budget for 2025 to the Assembly of the Republic Deputies. These changes and new initiatives should ensure that support reaches those who need it most, namely households experiencing energy poverty, instead of supporting free riders. Previous mechanisms required the beneficiary to finance the initial investment and wait for reimbursement in case the proposal was accepted, discouraging those most in need.

The Minister pointed out that there are 90 million euros earmarked for the Support Programme for More Sustainable Buildings (PAE+S), as part of the application for the Recovery and Resilience Plan (RRP), even though the 2023 call, still in force, has an allocation of only 30 million euros. To fill the gap for applications that were not addressed with the current 30 million, this programme will be reinforced, or a new call will open to implementing the budget, but it will be much less bureaucratic and less complex than the previous programme. Once the 60 million reinforcement phase for the Support Programme for More Sustainable Buildings is used up, the support programme for 2025 involves reinforcing the support aspect for vulnerable families, through two new mechanisms, more suited to those with fewer resources. In one case, the amount is given immediately, in the form of a voucher, to the citizen whose application is approved. On the other, the money is given to public and social sector organisations that finance the initial investment for home renovation:

- **E-Home scheme**: Similar to the existing Efficiency Voucher, this programme supports beneficiaries with the implementation of energy efficiency measures in their homes and the purchase of efficient domestic appliances. The idea is to be simple and quick, but such programmes require some control, monitoring and surveillance to ensure adequate use of the subsidy.
- **Sustainable Urban Areas programme**: It will support energy efficiency interventions, which include both thermal insulations of buildings and action in

public spaces, including green areas, **in urban areas with greater vulnerabilities.**

In this second programme, the money will go to parish councils, residents' associations, or Private Social Solidarity Institutions (IPSS), avoiding dealing with many applicants, but rather with a group of houses, with a facilitator. While this programme seems promising, it is set to target urban areas with greater vulnerabilities, so there are no clear indications about whether small villages are included. In rural areas, particularly in the inner and remote regions where the climate is more severe, the energy poverty problem is even more pronounced. Rural areas are prone to higher energy costs due to their location, influencing the type and size of the dwellings and the heating system. The probability of energy poverty in rural areas is therefore twice that of urban (more often detached houses, bigger size/volume, lack of insulation, lack of access to natural gas, large use of biomass for heating, poorer access to goods and services, lower income, etc.) with severe implications in people's quality of life, for example, weak indoor air quality and added costs in transportation. This problem is getting worse, and many rural areas, because of the low-quality living standards and degraded buildings, are being abandoned by younger generations and losing their identity.

This is where the RENOVERTY project becomes relevant by gathering the needs of vulnerable citizens, the knowledge of energy experts and the best practices associated with energy poverty alleviation to deliver tools and resources to guide vulnerable citizens in implementing energy efficiency measures.

1.4 Characteristics of the Coimbra Region of Portugal

Residential buildings represent the vast majority of the building stock in Portugal, namely 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, both single-family households (SFH) and multi-family buildings (MFB) do not have any thermal insulation. Buildings constructed between 1961 and 1980 are characterised by poor energy performance. For example, experts have studied the energy performance of Portuguese buildings and argue that buildings erected during the 60's, 70's and 80's 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 those situated in coastal areas. The main causes of low energy performance in these buildings are related to the construction materials, inspections, equipment, management, and human errors.

The Coimbra Region is made up of several parishes and small municipalities, most of which are rural areas. There are 1.5 million households in the region, 80% of which living in houses and 20% of which live in multi-apartment buildings [1]. Its population is considerably aged, with an aging index[2] of 203.9 against the Portuguese average of 157.4 and the EU27 average of 132.3. In 2018, the Gini Coefficient [3] (which measures the inequality of income distribution) in the region was of 4.7. Although with limitations regarding indicators and hard data, it is well known that the region has an at-risk-of-poverty rate[4] of 17.3%.

The dwellings are mostly energy inefficient and distributed across several municipal districts dispersed over the region, with different typologies. Concerning climates, there is a variety depending on the geographic location: the more inner places experience continental climates and suffer from very cold winters and hot and dry summers, while more coastal areas suffer from humidity and cold. Citizens face multiple vulnerabilities but share similar energy burdens and are unable to maintain adequately warm or cold households.

1.5 RENOVERTY in Coimbra: methodological approach

Through the codesign process with many relevant stakeholders (local power, municipalities and parish councils, housing associations, cultural associations, enterprises, LAGs, Cooperative for renewable energy (REC), construction cluster, academia and researchers), and by empowering existing buildings' inhabitants with the ability to achieve energy-efficiency in households that is equal to or better than the best reference buildings, RENOVERTY will go beyond what the Energy Performance Certificate (EPC) can achieve. Due to the owners' and users' participation in the process, from the diagnostic phase, through the design of the improvement measures and planning of the renovation works of the houses, energy recommendations tailored to the specific needs of local households have been made possible. This interaction is essential to demonstrate that effective energy efficiency is only possible by involving building managers, users and relevant energy stakeholders in the consultation process to yield optimal results that would benefit all interests.

[1] https://ine.pt/scripts/db_censos_2021.html
[2] Ageing index: number of people aged 65 and over for every 100 people under 15.
[3] INE-Statistics Portugal, Income and Living Conditions, 2019 (Provisional data), Available online: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=354099803&DESTAQUESmodo=2, (accessed on Dec 7, 2021)
[4] INE–Statistics Portugal, Income and Living Conditions, 2019 (Provisional data), Available online: https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUESdest_boui=354099803&DESTAQUESmodo=2, (accessed on Dec 7, 2021)

To ensure strong cooperation between key actors, the pilot region in the project has been limited to a radius of 70km from Coimbra, using partnerships with local authorities (municipalities and parish councils), social support entities and their technicians, local cultural associations and, especially, involving existing Local Action Groups (LAGs) as facilitators of RENOVERTY. LAGs have the responsibility to design local development strategies following Community-based Local Development (CLLD) territorial approaches, with close links to the social, economic and institutional fabric of each territory, with the aim of developing, diversifying and making the economy more competitive and improving people's living conditions. LAGs play a key role in the LEADER approach, an EU initiative under the Common Agricultural Policy (CAP) and the European Agricultural Fund for Rural Development (EAFRD), to promote sustainable development in rural and local communities.

Following in-person recruitment events, a total of 20 households were identified to learn about improving their household energy efficiency and potentially undergo energy audits, the latter of which would help families understand their household energy performance while simultaneously allowing for RENOVERTY to understand the average baseline energy efficiency of homes around the pilot site. More specifically, 10 vulnerable households expressed interest in conducting energy audits in each pilot area. A survey assessment and energy audits were performed by qualified experts among these households to characterize the different housing typologies, energy consumption, and specific building characteristics and issue the EPCs.

Based on the common methodology proposed by RENOVERTY, a renovation roadmap, acting as a practical guideline to help rural citizens combat energy poverty considering specific issues for each pilot was created with considerations specifically targeted towards the households in the rural region of Coimbra, including recommendations on the energy efficiency improvements to be carried out to yield maximum energy reductions with as few investments as possible, potential entities responsible for implementing these measures or assisting in their implementation, as well as programmes and financial instruments that can help support the initial investment for the renovation works. Some of the measures recommended may also include third-party investors, who can also be contacted to deliver their local support. This is the case of RE Communities that could require third-party investors and the involvement of local authorities (e.g., Municipalities, Social Support Entities, etc). The last section of this roadmap focuses on existing legislative, financial and administrative barriers to rural renovation and dives into potential conceptual solutions to tackle those, particularly by relevant stakeholders.

The activities in Portugal took place in two locations with distinct climates in the region of Coimbra, locations where energy poverty is quite severe, and where the facilitators were willing to engage with RENOVERTY activities. More specifically, RENOVERTY activities took

place in one inner rural district and another peri-urban district, closer to the coast, as can be seen in Figure 1. Location of the pilots in the Coimbra region.

Figure 1. Location of the pilots in the Coimbra region.

The first location is a small village, Vila Nova de Oliveirinha, located in the Municipality of a small town, Tábua, a mountainous region in the centre of Portugal, in the Region of Coimbra, where summers are hot and winters are very cold. The buildings are typically single-family houses, with poor energy performance. Although some buildings made of stone can still be found, the majority are brick (single walls). Most of the population still relies on wood burning (open fireplace) for their heating needs. In this location, the identification of households for the energy audits was carried out with the help of the local LAG (ADIBER) in collaboration with the local recreative association and the parish council.

The second Pilot is the small village of Arzila (around 650 inhabitants), part of the Coimbra municipality. It is located in the valley of the Mondego river, 30 km from the sea. Because of this, it has a fairly moderate climate, although rather humid. The village borders a marsh which is a natural reserve. The population used to rely on natural resources (fishing, agriculture) for their livelihood but now it is mainly a dormitory town with people working in nearby Coimbra. Buildings are all single-family houses, some semi-detached with poor energy performance. Most houses are over 30 years old and have not undergone renovation. Again, most of the population still relies on wood burning (open fireplace) for their heating needs. The identification of households for the energy audits was carried out with the help of the local LAG (CoimbraMaisFuturo), the local council and the local Ethnographic Group.

Figure 2 shows typical house in each rural area.

Figure 2. Typical House in Vila Nova de Oliveirinha and street view in Arzila

2 Technical considerations for the renovation of homes affected by energy poverty

This section presents the renovation roadmap that can be implemented in the rural region of Arzila, based on the energy audits carried out and the DREEM simulation model, focusing on the best renovation measures identified to improve the energy efficiency of the houses of vulnerable households. Some general considerations about the energy auditing process in Portugal, in the residential sector, are also presented because the issuing of Energy Performance Certificates requires an energy audit by a certified auditor.

2.1 Energy audit

An energy audit is a systematic inspection and analysis of energy use and energy consumption of a site, building, system, or organization with the objective of identifying energy flows and the potential for energy efficiency improvements and reporting them. In simpler terms, an energy audit provides detailed information about the energy characteristics of a dwelling, its energy systems and energy sources and provides a list of measures identifying potential measures to improve the overall energy efficiency of the building.

This type of information is crucial to fully understand energy poverty, as well as to address the identified contributing factors to its prevalence and severity, and as a final result, to be able to successfully reduce them via renovation. Based on the results of energy audits, energy performance certificates (EPCs) are issued for each dwelling. EPCs are important instruments that help improve the energy performance of buildings with a central role in the Energy Performance of Buildings Directive (2010/31/EU and 2018/844/EU together with a proposal for a recast COM/2021/802 final). Energy performance certificates provide information to consumers on buildings they plan to purchase or rent. They include an energy performance rating and recommendations for cost-effective improvements. Certificates must be included in all advertisements in commercial media when a building is put up for sale or rent. They must also be shown to prospective tenants or buyers when a building is being constructed, sold, or rented. After a deal has been concluded, they are handed over to the buyer or new tenant. Energy Performance Certificates should also disclose cost-effective ways and, where appropriate, available financial instruments to improve the energy performance of the building to the owners or tenants of the buildings.

In Portugal, the energy auditing legal framework for buildings is well established and has been in place for some years now, under a national regulation: DL 101-D/2020)[5], transposing the EPBD to the national law. Mandatory energy audits in buildings are connected to the Building Certification System[6] (SCE). This regulation establishes the requirements applicable to buildings for the improvement of their energy performance and regulates the Energy Certification System for Buildings. To obtain an Energy Performance Certificate, an energy assessment needs to be carried out by an accredited SCE technician (DL 101-2021)[7] following a specific auditing methodology. The Buildings Certification framework has its own rules and regulations, both for the audit procedures and for the experts' qualification/certification (Law n.º 102/2021, of 19 November[8]).

There is a specific methodology that needs to be followed to issue the certificates, but for the fieldwork, the auditors have the freedom to use the methods they want.

Nevertheless, without defining specific standards and methods, each framework provides a list of minimum requirements:

- Parameter to be quantified
- Characterized equipment
- Checked equipment
- Details on energy transformation and costs
- Load diagrams
- Evaluation of efficiency and specific energy consumption
- Identification of anomalies and opportunities for energy savings, etc.

SCE experts and technicians must meet specific background and experience requirements and successfully pass an examination administered by the National Energy Agency, ADENE, which is the Executive Body of this system. The DL nº 102/2020[9] establishes the requirements and the rules for the activity of the technicians. SCE technicians are independent professionals who work in the Energy Certification of Buildings (recognised by ADENE) and carry out their activity as Qualified Experts (PQ) for energy certification or as other SCE Technicians, such as technicians for the installation and maintenance of buildings and systems (TRM), as well as the management of building energy consumption (TGE) and periodic inspection of technical systems (TIS) covered by the SCE.

[5] Sistema de Certificação Energética de Edifícios, transpondo a Diretiva (UE) 2018/844 e parcialmente a Diretiva (UE) 2019/944.

[6] https://www.sce.pt/

[7] https://files.dre.pt/1s/2021/11/22500/0000600015.pdf Estabelece os requisitos de acesso e de exercício da atividade dos técnicos do Sistema de Certificação Energética dos Edifícios

[8] https://dre.pt/dre/detalhe/decreto-lei/102-2021-174614573 Estabelece os requisitos de acesso e de exercício da atividade dos técnicos do Sistema de Certificação Energética dos Edifícios

[9] https://files.dre.pt/1s/2021/11/22500/0000600015.pdf

Twenty energy audits were carried out in households experiencing energy poverty in the Coimbra pilot regions with the objective of issuing energy certificates and the corresponding technical reports, thus gaining real on-site data that serves as a sampling of the state of the housing stock on the territory.

Together with the LAGs and other local facilitators (local associations, chairman of the parish council, folkloric groups, philharmonic organisations, etc.), all of which are individuals trusted by the local community, the most vulnerable households in the region were mapped, identified and recruited to attend a raising awareness workshop in their villages, after working hours. The Institute of Systems and Robotics of the University of Coimbra, ISR-UC (a non-profit research institution associated with the University of Coimbra, made up of a multi-disciplinary team carrying out leading-edge research in several important areas of science and technology, to improve the quality of life and sustainable development) in its role of project partner, presented and explained the RENOVERTY project and engaged 10 households, who were keen on participating in project activities, through signing a memorandum of understanding. The next step was to schedule the audits, paid for by the project, which have now been carried out by EPC-certified experts. RENOVERTY partners joined each visit to collect additional information for understanding the main energy needs of each household and identifying any obstacles to achieving a higher energy performance, while providing households with tips for energy savings, and raising their awareness about the importance of improving energy efficiency and the impacts of renovations.

The auditors visited all households, took measurements and collected the necessary data for the evaluation of each household's energy performance. The data are used to issue the Certificate, identify potential energy efficiency improvements to be carried out and provide a list of recommendations, and as a baseline for Dynamic high-resolution dE-mand-sidE Management (DREEM) model simulations. The official draft EPCs were registered in the ADENE platform for each audited household.

Inhabitants' expectations were not very high, particularly regarding the potential improvements in the house insulation. There is not a problem of humidity inside, but inhabitants claim about air draughts. They were also keen on receiving the official EPC, because incentive programs for renovations often require the house to have a valid EPC, as requirement to apply, which costs around €200-€400 for a typical single-family house, depending on the type and size of the household, the complexity of the heating, cooling and ventilation system, the documentation provided, their proximity to the household, etc. Moreover, in Portugal, an EPC must be obtained by the building's owners if the building/house is to be sold or leased. The cost of the EPC could be an initial obstacle to the energy renovation process of households experiencing energy poverty.

A total of 8 SFHs were audited in site 2-ARZ, following national legislation for building certification[10], and the EPCs were issued. Due to difficulties in scheduling the on-site energy audits, two family houses in this pilot2 are characterised based on interviews. This information, collected through energy audits in the field and interviews, is the basis data for the analysis presented below.

These houses are typically occupied by two or more household members. The houses were built between 1980 and 2006, with an average construction year of 1984. They generally have no insulation, with old and inefficient windows and doors, and uninsulated roofs. The heating systems are mainly local wood heating with electric boilers for domestic hot water. There is no cooling system for the buildings under study. The majority of the houses are categorised in the energy efficiency classes D and F, with an average primary energy consumption of 251.4 kWh/(m²a).

Based on on-site measurements and the EPCs issued, In Pilot2, in Arzila, only one house falls under class F, four houses fall under class E and the remaining five houses fall under category D. It is relevant to note that for the same energy efficiency rate achieved, based on the existing official methodology, the annual primary energy needs allow for high variation within the same class, for example, for Class F, primary energy needs can range from 482kWh/m2 to 706KWh/m2.

The most recommended measures, based on the energy audits carried out, were the replacement of shower heads with energy-efficient ones (saving hot water also translates into saving energy because the need for hot water decreases), the replacement of existing glazed windows together with the installation of self-regulating openings, with/without manual closing, in windows/blinds/walls to enhance air ventilation and improve inside air quality, avoiding indoor humidity accumulation and mould. All but self-regulating openings, indicated specific investment costs and energy savings. No energy savings were associated with this measure.

If the decision to renovate the houses is made based on energy savings alone, the results of the energy audits are not very attractive as the return on investment is very long, particularly for households experiencing energy poverty.

2.2 DREEM MODEL simulations for the Rural Households in the rural region of Coimbra

In addition to the energy performance certification methodology, the DREEM model was employed to model energy use and develop future renovation scenarios applying an evaluation framework that determined the most suitable Energy Efficiency Measures in each pilot case study of the project. For the case study of the rural region of Coimbra in

[10] https://www.sce.pt/certificacao-energetica-de-edificios/consumidores/

Portugal, the household typology explored concerns a SFH typology equipped with a wood stove, to cover its heating. Considering the specificities of the rural housing stock, the following energy efficiency measures (EEM) were evaluated for the two RENOVERTY pilot regions:

- EEM_1 - Exterior walls insulation: Insulating the main walls of the building under study from the outside, which commonly have solid walls with no cavities.
- EEM_2 - Double-glazed windows: Replacing single-glazing windows with energy-efficient glazing (Double-glazed windows) to reduce heat loss.
- EEM_3 - Roof insulation: Insulated between and under the rafters of the roof itself, reducing the overall heat transfer coefficient by adding materials with low thermal conductivity (this measure applies only in the case of SFH).
- EEM_4 - Energy-efficient heating system (Boiler upgrade - gas): In this case, the dwelling's outdated heating system is replaced by an efficient gas boiler with a higher efficiency ratio.
- EEM_5 - Energy-efficient heating system (Boiler upgrade - biomass): In this case, the dwelling's outdated heating system is replaced by an efficient biomass boiler with a higher efficiency ratio.
- EEM_6 - Energy-efficient heating system (Heat pump): In this case, the dwelling's outdated heating system is replaced by a heat pump with a higher efficiency ratio.
- EEM_7 - Energy-efficient lighting: In this case, the conventional tube lights and bulbs (fluorescent lamps) are replaced by high-energy-efficiency ones (LED lamps).

2.2.1 Baseline

In the baseline scenario, modelling results indicate that the SFH typology equipped with a wood stove in Pilot2, Arzila, consumes around 37,009.5 kWh annually (almost 249.7 kWh/m^2), which are divided into 35,153.5 kWh for its heating needs and 1,856.0 kWh for its appliances needs.

DREEM simulations also lead to concrete quantifications regarding the impact of the different EEMs on the household typologies' energy performance. In the next sections, the energy savings of each measure in relation to baseline and techno-economic comparative analysis will be presented for the two pilot sites.

2.2.2 DREEM analysis results in terms of energy savings in Pilot 2, ARZILA

In the case of the SFH typology equipped with a wood stove in the rural region of ARZILA in Portugal, like in the first pilot, simulation results indicate that EEM_6, which involves replacing the existing heating system with a heat pump, also leads to the

highest amount of energy savings, namely 29,195.2 kWh per year (78.9% reduction compared to the baseline scenario), while EEM_3 leads to 14,503.6 kWh saved annually (39.2% reduction) and EEM_4 leads to reducing energy consumption by 12,951.9 kWh per year (35.0% reduction), as presented in Table 1.

Table 1. Comparison of annual total energy savings (kWh) for all EEMs with baseline in the rural region of Arzila.

Annual energy savings (in kWh) (SFH, Arzila, Coimbra, Portugal)		
	Energy savings (kWh)	**Reduction (%)**
EEM_1: Exterior wall insulation	1,310.1	3.5
EEM_2: Double-glazed windows	1,972.6	5.3
EEM_3: Roof insulation	14,503.6	39.2
EEM_4: Boiler upgrade - gas	12,951.9	35.0
EEM_5: Boiler upgrade -biomass	8,789.7	23.7
EEM_6: Heat pump	29,195.4	78.9
EEM_7: Energy efficient light bulbs	277.2	0.7

In relation to the techno-economic assessment, based on the three most common indicators: net present value, payback time and levelized cost of saved energy, the results of the different EEMs for the SFH typology in Arzila are presented in Table 2.

Table 2. Technoeconomic assessment of the different EEMs in the SFH in the rural region of Arzila (no subsidy).

	Investment Costs (€)	Lifetime (years)	Discount Rate (%)	NPV (€)	PP (years)	LCSE (€/kWh)
EEM_1	5,033	30	4.00%	-4,032.9	>lifetime	0.222
EEM_2	7,700	30	4.00%	-6,194.5	>lifetime	0.226
EEM_3	1,022	30	4.00%	10,047.7	1.7	0.004
EEM_4	900	20	4.00%	-12,167.0	-	0.009
EEM_5	2,500	20	4.00%	2,092.9	8.9	0.027

EEM_6	3,000	20	4.00%	8,977.3	3.7	0.009
EEM_7	50	23	4.00%	378.7	1.8	0.012

According to the analysis, EEM_3 (Roof insulation) and EEM_6 (Heat pump) demonstrate the best performance in terms of NPV, with NPVs of €10,047.7 and €8,977.3, respectively. EEM_3 (Roof insulation) and EEM_4 (Boiler upgrade- gas) result in the lowest LCSE, at €0.004/kWh and €0.009/kWh, respectively. Additionally, EEM_3 and EEM_7 exhibit the best performance in PP, with 1.7 and 1.8 years, respectively. Furthermore, in the case of EEM_1 (Exterior wall insulation) and EEM_2 (Double-glazed windows) financial support is identified as necessary, while in the case of EEM_4, the use of gas leads to higher running costs characterising this alternative as an unattractive solution.

When the energy-saving potential and cost-effectiveness of the EEMs are co-related, as shown in Figure 3, the replacement of the existing heating system with an energy-efficient heat pump (EEM_6) is the most cost-effective measure (energy savings: 29,195.5 kWh/year, LCSE: 0.009€/kWh), followed by EEM_3 and EEM_4. On the contrary, EEM_2 and EEM_1 are shown to be the least cost-effective EEMs due to their higher LCSE values.

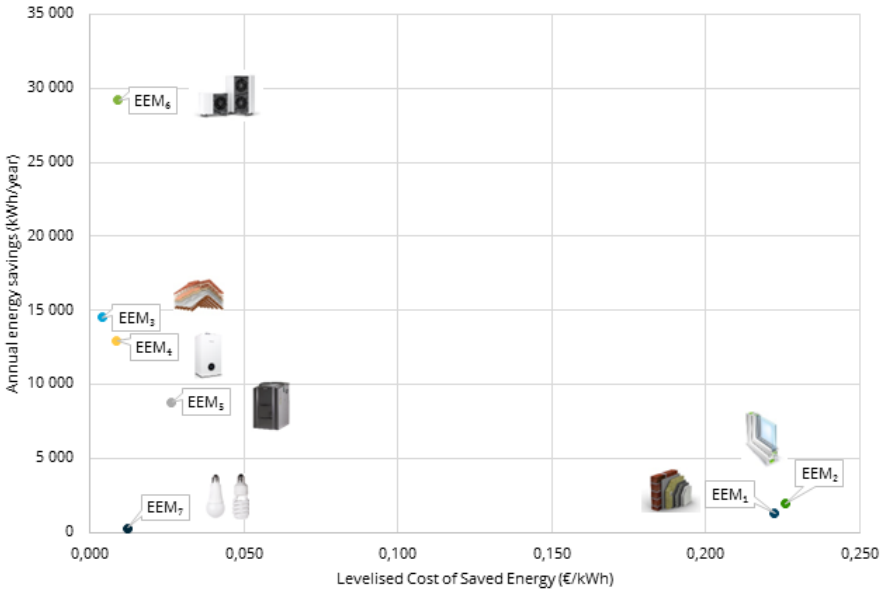


Figure 3. Energy-saving potential and cost-effectiveness of the EEMs under study in the case of the SFH typology in the rural village of ARZ.

Additionally, the correlation between NPV and cost-effectiveness of the different EEMs under study was analysed. As indicated in Figure 4, EEM_3, EEM_6, EEM_5 and EEM_7 rank highest, as they include the best combinations of NPV and LCSE. In contrast, EEM_2, EEM_1, and EEM_4 rank lowest, with negative NPVs and higher LCSEs, indicating less attractive investments.

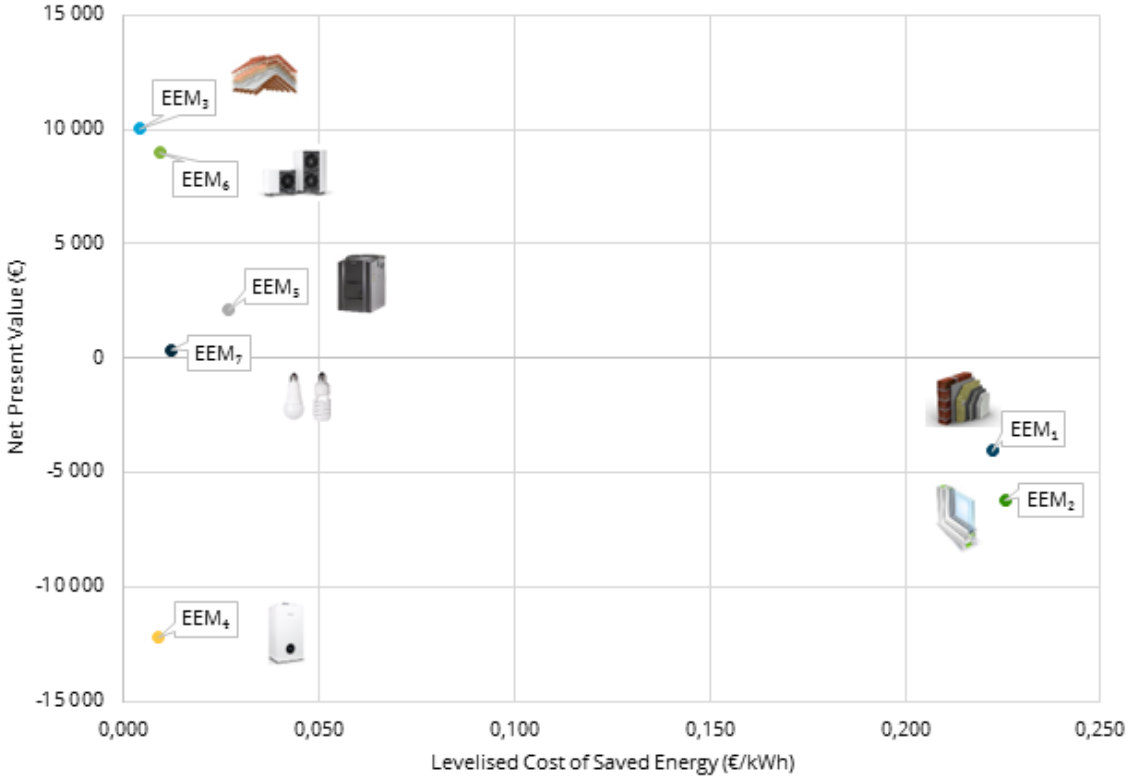


Figure 4. Profitability and cost-effectiveness of the EEMs under study in the case of the SFH typology in the rural village of ARZILA.

The same ranking among the different EEMs is observed in the case of the different subsidisation levels leading to increased cost-effectiveness and profitability, due to the lower LCSEs and the higher NPVs, for the same amount of energy savings achieved. EEM_1 and EEM_2 lead to positive NPVs for a subsidy level of more than least 75%, while the NPV of EEM_4 remains negative at all subsidy levels.

In addition to the information herein presented, some scenario analyzes for the techno-economic assessment of the EEMs for different subsidy rates (25%, 50%, and 75%, respectively) were carried out. In all three scenarios, the ranking of the various EEMs remains consistent; however, the economic benefits for households facing energy poverty increase significantly in terms of NPV and LCSE, while the PP is reduced. This means the impact of the different subsidy rates is more pronounced for EEMs with initially higher PP and LCSE, and lower NPV. This demonstrates that subsidies can substantially enhance the financial viability of EEMs, especially those with higher upfront costs and longer PPs. In particular, interventions in the building envelope, EEM1, and energy efficient windows, EEM2, are only attractive if the subsidy to cover the upfront costs is at least 75% the investment.

2.3 Considerations for homeowners

This section offers practical guidance on implementing energy improvements for family houses, from step-by-step planning to presenting viable solutions, supported by calculations from the energy audits and the DREEM model.

2.3.1 Energy Performance requirements in Portugal – legislative framework for renovations

The implementation of the Energy Performance of Buildings Directive (EPBD) in Portugal commenced in 2007, guided by three decrees issued in 2006. Subsequently, in 2013, the legislation underwent revision to align with the new stipulations of Directive 2010/31/EU. Between 2019 and 2020, the Portuguese government undertook a comprehensive review of existing legislation to align it with the provisions of Directive (EU) 2018/844. In recent years, the focus of EPBD implementation in Portugal has centred on updates and minor adjustments, building upon the groundwork laid in 2013. However, certain aspects of current regulations require revision to ensure full compliance with the EPBD, including adjustments related to requirements for renovated building elements.

Presently, when a specific building component (such as the building envelope or technical building system) undergoes renovation, minimum requirements are applicable. In such cases, energy efficiency is systematically improved “part by part”, ensuring that each new component functions at a level equivalent to that of a new building. In the context of deep renovations, an overall assessment is mandated, necessitating the attainment of a minimum performance standard for the entire building. In these instances, it may be imperative to replace or enhance additional elements to meet the stipulated minimum threshold. Notably, technical building systems, without exception, are subject to these enhancements, with the minimum efficiency of equipment currently surpassing the standards set in 2013. Stricter requirements for existing residential buildings come into play exclusively when these buildings undergo renovations. The building component slated for renovation must adhere to the minimum performance levels as defined by prevailing regulations.

Within the framework of the Portuguese Long Term Renovation Strategy (LTRS), a set of cost-effective approaches to building renovations has been identified. The LTRS incorporates four distinct renovation packages, each applied based on the building's needs. These packages are set to be progressively and cumulatively implemented until 2050, prioritising the renovation of the worst-performing segments of the building stock. The strategy encompasses various measures, including:

- The rehabilitation of passive building components (windows, walls, and roofs) to ensure acceptable levels of thermal comfort without increasing energy consumption.

- The replacement of existing electrical equipment, air conditioning (AC) systems, and lighting systems with more efficient alternatives.
- The integration of local Renewable Energy Source (RES) production systems, such as solar thermal and photovoltaic panels, along with storage systems (batteries).
- The installation of highly efficient AC systems in buildings that, despite undergoing rehabilitation, still require such systems to ensure adequate thermal comfort, particularly in more severe climatic zones.

In Portugal, a renovation is considered deep when more than 25% of the building's value is spent on building elements. Since its mandatory introduction in 2009 for rent or sales transactions, the EPC has become widely accessible to the public. The use of EPC has seen a notable increase due to the mandatory advertisement of the EPC label before buildings are rented or sold, a responsibility shared by both building owners and real estate agents. Instances of non-compliance are now more regularly addressed, largely because notaries, in accordance with regulations, are obligated to report transactions that occur without an existing EPC. In such cases, building owners or real estate agents are required to rectify the situation by issuing the EPC and providing it, free of charge, to the new owner.

2.3.2 Setting renovation expectations and indicators for rural households

Based on the energy audits and field measurements and semi-structured interviews with households by then, it was possible to identify the most relevant problems, concerns and desires of the inhabitants. This information allows to identify the indicators in these rural areas people would consider to begin a renovation and why, as presented in Table 3.

Table 3. Main renovation indicators and indicator range expectations.

Goal	Indicator	Indicator range
Increase thermal indoor comfort	indoor temperature in summer /winter	19-22 ºC in winter 25-28ºC in summer
Reduce air draughts inside the house	Existence of mold in walls	No mold
Reduce water consumption	Nº of cubic meters per person	Reduce hot water consumption: Benchmark is xxm3 per person; efficient shower heads reduce water consumption by 20%
Reduce the rheumatoid disturbances (better flexibility without joint pains) Increase happiness and joy of living	Health impacts: number of visits to hospital/doctor. Medicines bill	reduce doctor visits by half Start doing exercise.

Availability of local resources	Higher sustainability and lower dependence	Since Fuel wood is an important resource for heating in rural areas but causes many air quality problems, indoors and outdoors: One heat recovery system per house.
Awareness raising, ability to understand energy bills	Increase in Energy and digital illiteracy levels	set up an itinerary one-stop-shop (OSS), mobile truck/van to park once-twice per week in the pilots
Reduce energy bills	KWh saved € saved	Overall, 20% savings in relation to baseline

2.3.3 Typical steps of the renovation process in Portugal

The renovation process in Portugal is not simple or quick. Depending on the tenure, type and state of the house, the renovation process may be a nightmare, and in general, households postpone renovation works. However, the renovation process of SFH is more straightforward, as decisions regarding renovation can be made bilaterally at the household level and do not require the approval of multiple households or property managers, as would be the case in a condominium or MFB.

The main steps of a renovation process can be described shortly as indicated in Figure 5, and a brief overview of each step and key stakeholders to be involved are presented in the following paragraphs.

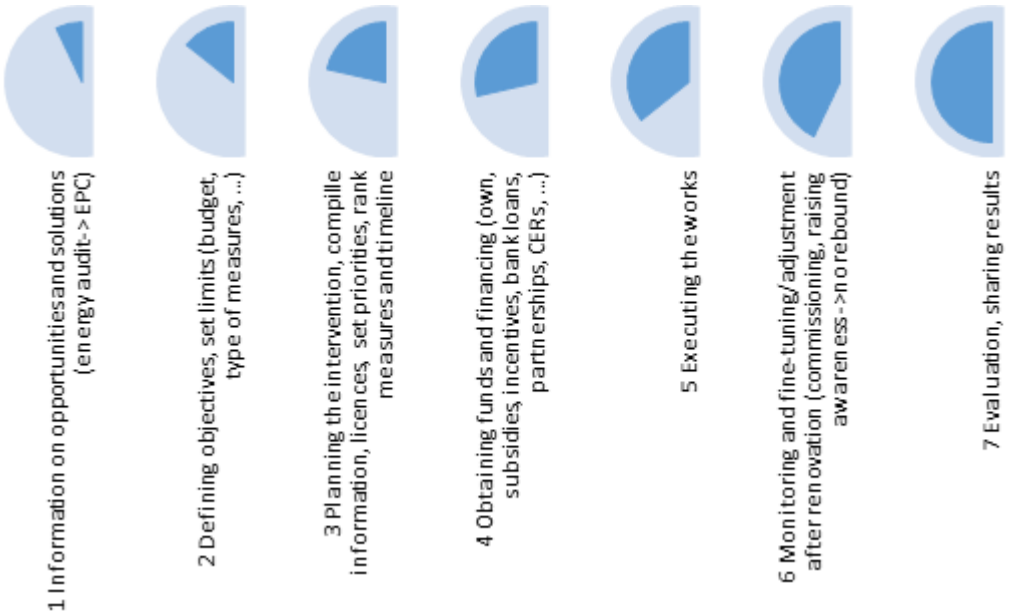


Figure 5. Renovation steps.

Step 1: Information on opportunities and solutions

Key stakeholders to be involved: local power, LAGs, one-stop shops/balcão energia, energy agencies, energy auditors, NGOs

The renovation process starts with an initial assessment that is carried out to gather information to identify the energy problems in the home as well as opportunities for improvements and the most appropriate solutions. As a result of this energy audit, an Energy Performance Certificate will be issued, as an energy ID of the home.

- the energy audit will analyse current energy consumption, and identify problems such as lack of insulation, old and inefficient equipment, leaks and thermal bridges. This exercise will determine monthly energy costs, and possible gains and the EPC will provide a set of recommendations for improvements along with its costs.

- the suggested recommendations can be ordered by the priority of intervention, according to the rationale of preference or convenience: vulnerability/immediate impact of the intervention; economic cost/benefit of each measure.

Step 2: Definition of renovation objectives

Key stakeholders: energy auditors, financing entities, legal/governmental entities

An energy renovation process primarily aims to improve the performance of the house by reducing energy costs while increasing indoor comfort. But, depending on how deep the renovation is, the impact and the costs should be considered. It is a good practice to establish some objectives before entering the process. The good practices indicate:

- reduce energy consumption by at least 20% and improve the thermal comfort of the house as long as possible for the recommended values: T inv >=18º; H inv <50%
- implement on-site energy production solutions based on renewables (in Portugal, due to the number of sun hours, installing solar thermal to reduce DHW energy consumption is a good practice)
- establish a maximum ceiling for the budget to spend on renovations

Step 3: Intervention planning

Key stakeholders to be involved: OSS/Balcão energia, local government, energy agencies, local cooperatives, local contractors and installers

Before starting the work, good planning is needed to avoid undesirable surprises during the overall process. The main aspects have to be considered:

a) preparation of information on the technical state of the building and the renovation works to be carried out, as well as preparing the necessary documentation to submit an application for financial support. Here, OSS, parish councils, housing associations, and energy agencies can provide advice and free support.

b) according to the budget and the needs, it is recommended to prioritise the implementation of the identified improvement measures, following the categories:

- High: Interventions with the greatest impact, such as thermal insulation and window replacement.

- Medium: Updating heating, ventilation and lighting systems.

- Low: Aesthetic changes or those not directly related to energy consumption

c) As well as to establish a timeline for the execution of the works in phases, according to urgency, budget and financing conditions.

Step 4: Obtaining resources and financing

Key stakeholders to be involved: local government (municipalities and parish councils), central government, LAGs, ESCOs, banks, solidarity institutions, cooperatives and associations

Financing the works is not the only constraint preventing renovation works from being carried out but is for sure the main barrier for vulnerable citizens. Before starting the works, it is necessary to be sure about financing means:

- there are some subsidies and incentives provided by the government (for example: Casa Eficiente and energy efficiency vouchers) that can leverage the works.

- some banks provide bank loans for energy renovations with low interest rates (lower than the market)

- partnerships with NGOs, parish councils, or local companies that can help to access other financing mechanisms (REC, energy cooperatives)

- there are also support tools for simulating the benefits (energy savings, better living conditions, more comfort, and better health) and return on investment in a simple and easy-to-understand way.

Step 5: Execution of the works

Key stakeholders to be involved: local contractors and installers, intermediators/middle actors (firefighters and cultural associations), parish council, volunteers (NGOs)

After the study analysis and good planning, it is time to start the work, which includes several stages. Depending on the type of improvements to be carried out, the main works are:

- improvements to insulation (walls, roof, windows).

- upgrading or changing the heating or cooling systems.

- installing renewable energy sources, such as solar panels.

- replacing old domestic appliances with efficient models (class A+ or higher).

Ensuring the contractor is credible and works well should be a primary concern. Some energy agencies provide a list of reliable contractors.

Step 6: Monitoring and fine-tuning/adjustment after renovation

Key stakeholders to be involved: installers, OSS/Espaço Energia, regional energy agencies, volunteers (NGOs)

If the renovation works are crucial, the good use and practices after the works have a strong impact on the overall performance and avoid bad surprises when the energy bills have to be paid. Regular monitoring of energy consumption is necessary to check the results, fine-tune and avoid the rebound effect:

- Commissioning, through adjustments, reprogramming thermostats and lighting systems to the recommended levels, as well as checking the connection of renewable energies (especially solar thermal) with the other DHW systems, to avoid waste and unnecessary consumption of gas and water.
- Informing, motivating and making inhabitants aware of the best use of equipment and resources, making them realise the impact that bad practices can have on energy and water bills, as well as the importance of some good practices (ventilation of spaces) for the health of people and the house itself.

Step 7: Evaluation and follow-up

Key stakeholders to be involved: OSS, local cooperatives, national Energy Agency (Energy Poverty Observatory), LAGs, (utilities)

Last but not least, documenting the gains made in energy savings will help to report the impact on comfort and on the market value of the home and make it possible to share and publicise the experience on social networks or local events to inspire others.

This roadmap can be adapted to the specific needs of the household and local legislation. Many energy renovation projects, especially those carried out in partnership with governments or NGOs, as it is the case of social housing and households facing severe poverty and housing problems, include consultants who help align and commission the overall planning to each specific case, based on the best practices and resources available in each area.

2.3.4 Funding the renovations

The main concern for households experiencing energy poverty and who are interested in carrying out energy renovation lies with uncertainty about how to finance the renovation. Several possible financing mechanisms as well as the main barriers for each option identified, are outlined in Table 4. It is also possible to understand how long it takes to have access to the different options.

Table 4. Financing options time to wait for financing approval and main barriers identified for each type of financing).

	Financing options	2month					Barriers
	Own						Economic poverty; vulnerable people may not be able to afford the works
	Bank loan						Bureaucracy and cost of money; time for decision and collaterals
	Subsidy						The share of the subsidy is too low; the subsidy comes after upfront costs are charged, if the application is eligible;
	Match funds						Misalignment between social, development and housing/energy policies; split incentives; solidarity&Charity Institutions typically more focused on providing health services
	Fundraising campaign [11]						Portuguese citizens are very supportive and altruistic; when called upon for solidarity, they are very helpful. But there is no public consciousness about the vulnerability of the peers.
	REC						Difficult to understand the business model and lay people still mistrust REC

Once the options are identified, applying for funding must be done before starting the renovation work. Some government instruments in Portugal help support the energy renovation of buildings. However, the existing schemes are not designed to address people who cannot afford the upfront costs nor are targeting rural areas in particular. By the time of writing this report, the only programme available for subsidy renovations targeting vulnerable citizens is the First Right (1º Direito), which aims to support the promotion of housing solutions for people living in undignified housing conditions who do not have financial capacity to bear the cost of access to adequate housing. This

[11] Example of a possible idea: set a crowdfunding campaign during Christmas time – organize a concert or dinner to raise funds for new roofs, …

programme is not available for individuals, but municipalities, or other organizations[12] that can promote housing solutions, to provide financing for a larger number of households in an aggregated manner:

https://www.portaldahabitacao.pt/web/guest/1.%C2%BA-direito;

More sustainable buildings

Until recently there was a support Programme for More Sustainable Buildings as part of the Recovery and Resilience Facility. This nationwide programme has an execution period until 2026 to implement a set of reforms and investments aimed at driving the country on the path to recovery, sustained economic growth and convergence with Europe over the next decade. Aligned with European climate targets, and committed to decarbonize the economy until 2050, six intervention components in strategic areas are designed in this programme, one of which is component **C13 - Energy Efficiency in Buildings**. The objectives of pillar C13 are to rehabilitate and make buildings more energy efficient, providing social, environmental and economic benefits for people and companies. The funds available for the first call of this programme were not enough for the proposals submitted in 2024, and now, another call is to be launched. Potential improvement measures include:

(-) Replacement of inefficient windows with efficient windows of energy class "A+".
(-) Application or replacement of thermal insulation:
(-) in roofs and pavements
(-) in walls
(-) doors
(-) Space heating and/or cooling and/or domestic hot water systems (DHW), using renewable energy, of energy class "A+" or higher:
(-) heat pumps
(-) Solar thermal Systems
(-) High Efficiency biomass boilers and heat recovers
(-) Installation of Photovoltaic Solar Systems and other equipment for the production of renewable energy production for self-consumption with or without storage
(-) Interventions aimed at water efficiency
(-) Interventions to incorporate bioclimatic architecture solutions, involving the installation or adaptation of fixed building elements such as shading, greenhouses and roofs or green façades, favouring natural base solutions.

FUND of the Regional Operational Programme - IFRRU

This financial instrument mobilises the funds approved by the Regional Operational Programmes (Portugal 2020, Portugal 2030) with the objectives of revitalising cities, supporting the physical revitalisation of the space dedicated to disadvantaged

[12] Autonomous Regions or Municipalities; Public organisations; 3rd Sector: residents' associations and housing and construction co-operatives; Owners of properties located in run-down neighbourhoods.

communities and supporting energy efficiency in housing. The fund is complemented with financing from the European Investment Bank (EIB) and the Council of Europe Development Bank. The IFRRU provides loans at more favourable conditions than those available on the market, for the full rehabilitation of buildings, whether for housing or other activities, including the most appropriate integrated energy efficiency solutions within the scope of that rehabilitation.

https://ifrru.ihru.pt/web/guest/candidaturas#PEDIDO_DE_FINANCIAMENTO

Efficiency Voucher (C13-i01)

The efficiency voucher is a one-time financial incentive attributed to vulnerable households that are already recipients of the social energy tariff mechanism or receive other social support from the state (eligibility criteria). This instrument was launched by the COVID-19 crisis and another round of the Energy Efficiency Voucher Programme, is about to be released, supported by the National Environmental Fund[13]. Unlike the first programme, this time it will target Energy Poverty only, to avoid free riders. This financing scheme for economically vulnerable families will support works that improve energy performance and living conditions, namely in terms of windows, domestic hot water heating systems, space heating and cooling systems, and photovoltaic systems or others that use renewable sources; The maximum amount per HH will be 3900€ (1300€ per voucher). There are no details about the date the programme will open but the ministry promised to ease the application process.

Replacement of inefficient windows with efficient windows, with minimum energy class "A"; exterior solar protection (blinders or shadows); heating and cooling systems and domestic hot water (high-efficiency heat pumps; solar thermal, efficient biomass boilers and heat recovering; installation of PVs).

Fiscal benefits: reduced VAT for renovation works

The application of a reduced VAT on invoices from urban rehabilitation and Contracts for improvement, remodelling, renovation, restoration, repair, or conservation of buildings or autonomous parts thereof used as dwellings.

2.3.5 Phased planning

Within the RENOVERTY project, the roadmap aims to help households living in rural areas and experiencing energy poverty improve their indoor comfort conditions and provide

[13] In order to ensure that environmental policy is more effective, it was decided that the programme of the 21st Constitutional Government should include the creation of a single Environmental Fund, concentrating the resources of the existing funds so as to obtain an instrument with greater financial capacity and greater adaptability to the challenges posed.

them with information on existing programmes and financing mechanisms they can apply to, while also facilitating and triggering energy renovations in rural areas.

There is no incentive programme available for supporting renovations in Pilot 2. One possibility is the second round of the Energy Efficiency Voucher Programme (Environmental Fund) that should be launched in April. This time, the specific target will be households experiencing energy poverty. The efficiency vouchers can support some works that improve energy performance and living conditions, namely windows, DHWS, space heating and cooling systems, PVs, or other uses of renewable sources (biomass). The maximum amount per household will be 3900€ (split in three vouchers per household: 3*1300€) and the process to apply should be straightforward. The Parish council will play a role in this case, to facilitate the delivery of the vouchers.

That being said, based on the energy audits and DREEM simulations, the roadmap proposes a set of energy efficiency measures to be carried out by priority, according to the criteria cost/savings, and indicates typical costs of implementation for each measure as well as available possibilities to finance the improvements. This information is shown in Figure 6 for Arzila.

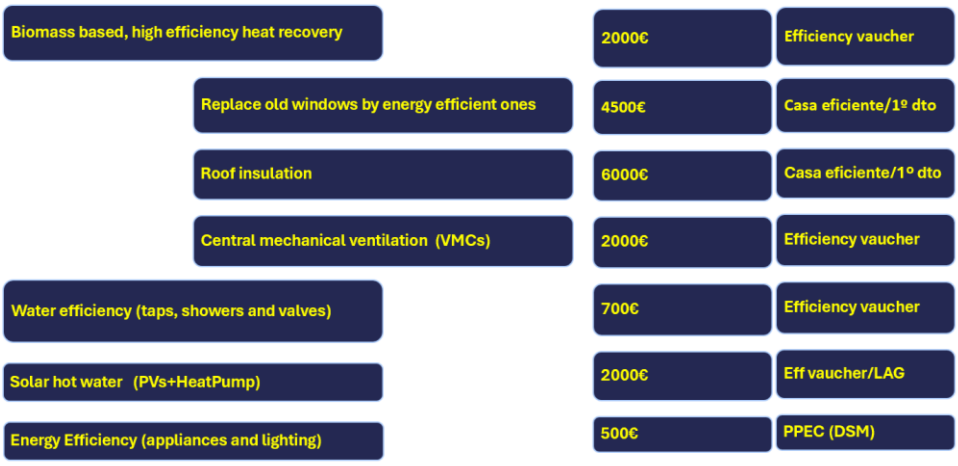


Figure 6. Schedule the proposed renovation measures by their importance of priority, costs and source of financing in ARZ.

Biomass-based, high-efficiency heat recovery, solar hot water system based on PVs + Heat pump, energy-efficient appliances and efficient taps, showerheads, and valves for water are the measures proposed by the roadmap with the highest importance, followed by roof insulation, replacement of old windows by more energy efficient ones and installation of central mechanical ventilation (VMCs) with lower priority.

2.4 Additional available tools and resources in Portugal to support households with energy issues

According to the developed requirements for the renovation of the houses, the selection of construction companies can be carried out following a tendering process, or direct adjustment (it depends on the value of the works and on the legal status of the entity to submit the proposals). In either case, one should always ask for a quote from different construction companies and compare their proposals, to ensure the best proposal is chosen. An alternative is to look for construction companies that are certified to carry out the renovation works within quality standards, which are available from the National Energy Agency. Besides choosing reliable builders, the materials and the technical equipment to be installed should also comply with the best available standards, particularly efficient windows, high-efficiency heat pumps, etc. Therefore, to ensure the implementation of the best renovation practices and quality works, contractors should sign a memorandum for the execution of rehabilitation works within quality requirements. Some existing platforms, for example, REVERTER-HUB, a sister project that addresses energy poverty in Social Housing in Coimbra (https://renovar.coimbra.pt/servicos-e-informacoes-uteis/), and the ADENE portal Casa+ (https://academia.adene.pt/portal-casa-o-balcao-unico-digital-da-eficiencia-e-sustentabilidade-nos-edificios/), provide lists of reliable contractors and or materials for reference.

Table 5 compiles a list of relevant available resources that can assist in the process of choosing the right supplier or the best technical solutions.

Table 5. Tools and resources available in Portugal.

Balcão único de energia | RENOVAR.Coimbra.pt	The first one-stop-shop serving the centre region of Portugal, capable of providing information, guidance and energy rehabilitation services to vulnerable households, supporting their enrolment in financing programmes to improve energy efficiency, health conditions and home comfort, in order to increase their interest in energy rehabilitation by providing access to relevant information to support decision-making from the earliest stages of the process.
Online platform offering information and services	https://www.pearlsofportugal.com/pt-pt/servicos/renovacoes-energeticas-portugal/
Menu Verde	https://www.menurenovacaoverde.pt/pt/em-todo-o-pais/financiamento/?buildingTypeSlug=casas

Novo Gabinete de Aconselhamento de Energia (GAE) – DECO DECO PROteste provides support and better loan conditions Credit Line | Partnership with BANKINTER geral@protestecredito.pt	DECO PROteste Crédito, in partnership with Bankinter, guarantees all subscribers and their families the best conditions on the market for home loans for purchase, construction, works or transfers. Take advantage of exclusive benefits such as exemption from the study commission (save €270.40), a spread from 0.75% (variable rate), a reduction of up to 0.15% in the fixed and mixed rate, reimbursement of transfer charges and a salary account with no charges.
Casa+ Platform https://portalcasamais.pt	The casA+ portal is an initiative aimed at property owners or tenants, enabling them to: - consult and record the characteristics of their property and find out how they can improve and enhance it - access energy efficiency solutions and information that will enable them to save on their energy bills and gain in comfort and health - centralise all relevant information about your home in one place - find the best professionals and companies offering energy efficiency and renewable energy products and solutions; - find incentives and financing solutions to support improvements towards more efficient and comfortable homes.
Construction company	Contractors from the region, to help local economy and promote green employment, who are known for their business ethics and reliability both in terms of time delivery and quality achievements, ideally contractors that adhere to Casa+ or are certified for Passive House standard.
Voluntary labelling system for windows - CLASSE+ labelling classemais.pt CLASSE+ energy labelling is an initiative of ADENE - Agência para a Energia (Energy Agency) and is an instrument available to citizens to help them choose more efficient windows, using the best companies and the best professional installers. **Demanding the CLASS+ label on proposals** and/or quotes is the first step toward a more informed choice. As a voluntary reference labelling system, CLASSE+ allows companies to distinguish themselves in the increasingly competitive construction and renovation market. By classifying their products	

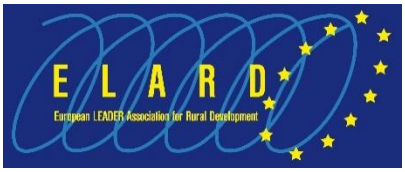
and services according to CLASSE+ technical rules and standards, companies demonstrate the performance of their products and reinforce the trust of their customers. The CLASSE+ energy label makes it possible to find out and compare, in a clear and simple way, the energy performance of products, materials and solutions. Only companies adhering to the CLASSE+ system can issue these labels and thus show the energy performance of their products, making it known to their customers and the general public.	
Windows	The first product to receive the Class+ label is windows. In the link below, a list of companies that are currently members of the CLASS+ system, with an emphasis on those that show the greatest involvement with the brand, is available: https://www.classemais.pt/classe-a-eficiencia-tem-classe/encontrar/#empresas Members are distinguished between: - System owners, who supply their frame systems to window manufacturers - Glass producers, who supply glass to window manufacturers - Window manufacturers, who produce the windows themselves, supply them directly (usually including installation) to the end customer or via other installation companies or resellers.
Building materials (insulation and paints will come soon)	Class + insulation materials and class + paints will be available in the future.
European Labelling:	
Sanitary equipment	Replacing old inefficient showers with efficient showers was recommended in all households. In Portugal, and particularly in rural areas, there is no consciousness about the importance of saving water, because water is not very expensive and many use water from their own wells for several tasks. Moreover, inhabitants do not realise the overall connection between water consumption and energy consumption. All major retailers provide energy-efficient showers which can be installed immediately, as well as water pressure reduction valves that can be easily installed in the pipes.

Air conditioning systems	High efficiency heat pumps, ideally with a COP above 4 are the ideal technology for moderate climates, and there are incentives for buying heat pumps (Vale Eficiência II). Moreover**, qualified heat pump installers** are recommended, because a bad installation can compromise the potential energy savings. https://www.fundoambiental.pt/ficheiros/2024/c13-aac_pve_2fase_-vf1.aspx
Renewable Energy Communities: In the centre region, there are two main companies investing in REC based business models.	
https://www.cleanwatts.energy/energy-poverty	Cleanwatts make clean energy affordable for all with digital tools that nurture energy communities with smart resource utilization. Cleanwatts helps communities and local businesses harness the benefits of the energy transition where it matters most, locally.
https://www.coopernico.org/	Coopérnico is an energy cooperative that promotes the involvement of citizens in the creation of a new social, economic and environmental paradigm. Together with the associates, it aims to develop renewable energy projects and share the benefits between investors, society and the planet.

2.4.1 Future perspectives

In the future, middle actors will play a crucial role in the success of the REERs. The blending of financing opportunities needs to be promoted and stimulated by the government to deploy home energy services particularly targeted and tailor-made for rural areas. The person/entity, responsible for the work, control and monitoring of the renovation to ensure that it is carried out in accordance with the project, will be identified by the local government specialist. Before starting the work, each household can apply for additional funding as well, as there are some government instruments in Portugal that support the energy renovation of households experiencing energy poverty as listed in the previous section.

Match funding, and blending of financing opportunities - the LAGs can have a key role in stimulating engagement of different stakeholders, to channel financing for home energy services. The creation of a “green lane” for vulnerable rural households, in the case of lines of incentives and subsidies, would have a major impact on the undeveloped rural areas.



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