NOVA SCHOOL OF SCIENCE & TECHNOLOGY

DEPARTMENT OF ENVIRONMENTAL SCIENCES AND ENGINEERING

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BSc in Environmental Engineering Sciences

ANALYSIS OF FINANCING SCHEMES TARGETING ENERGY EFFICIENCY AND ENERGY POVERTY MITIGATION

Case Studies: EUROPEAN UNION, UK, AUSTRALIA, AND NEW ZEALAND

INTEGRATED MASTER IN ENVIRONMENTAL ENGINEERING

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Abstract

Over the past few years, climate change has been increasingly acknowledged. In the European Union (EU), energy production and consumption account for 80% of total greenhouse gas emissions (GHG), and one of the most impactful consumption sectors is the construction industry. In addition, existing buildings are inefficient, exacerbating the situation of energy poverty (EP). This is characterized as a condition in which households lack access to energy services and products. However, according to the Intergovernmental Panel on Climate Change (IPCC) Special Report of 2018, energy efficiency (EE) and building renovation are two key factors in achieving carbon neutrality, yet renovations remain infrequent.

The main objective of this study is to explore and compare financial instruments to combat EP and/or promote EE in residential buildings in the EU, UK, Australia and New Zealand to understand the best features and success stories for future applications. Research methods included desk research, database search techniques, and snowballing techniques. In addition, interviews were conducted with selected experts on energy poverty, renovation policies and energy efficiency. With all the methodologies applied, 33 financing programmes and eight consumer protection policies in different countries were selected for the study. Among these programs, twelve underwent a more detailed analysis.

Some of the findings indicate that schemes exclusively targeting energy poverty witnessed the majority of measures being fully funded, with financial support reaching 100%. The most prevalent financial instruments in the studied programs were grants, with the majority of funding originating from European funds, except in the cases of New Zealand and Australia. Regarding specific measures, insulation and the installation of heating and cooling equipment were the most frequently encountered.

Considering the analyses conducted and the obstacles highlighted in the interviews, several conclusions can be drawn. A collaborative approach among diverse stakeholders is crucial for the establishment and development of these schemes. Furthermore, the implementation of assessment indicators and a monitoring methodology is essential to verify program success and ensure transparency. Lastly, integrating EE incentive programs with strategies to reduce EP, particularly focusing on deep renovation measures, is vital for reducing carbon emissions, enhancing energy access, and contributing to a more sustainable and equitable future.

Resumo

Ao longo dos últimos anos, as alterações climáticas têm sido cada vez mais reconhecidas. Na União Europeia (UE), a produção e utilização de energia são responsáveis por 80% do total de emissões de gases com efeito de estufa e um dos sectores de consumo com maior peso é o sector da construção. A par disso, os edificios existentes são ineficientes, piorando a situação de pobreza energética. Esta caracteriza-se como uma situação em que os agregados familiares não têm acesso a serviços e produtos de energia. No entanto, de acordo com o Relatório Especial do IPCC de 2018, a eficiência energética (EE) e a renovação de edifícios são dois pontos-chave para alcançar a neutralidade carbónica, mas as renovações continuam a ser pouco frequentes.

O principal objetivo desta dissertação é explorar e comparar instrumentos financeiros para combater a PE e/ou promover a EE em edifícios residenciais na UE, Reino Unido, Austrália e Nova Zelândia para compreender as melhores características e histórias de sucesso para a conceção de um esquema modelo. Os métodos de investigação incluíram o método de pesquisa documental, técnicas de pesquisa em bases de dados, e técnicas de snowballing. Além disso, foram realizadas entrevistas com peritos selecionados sobre pobreza energética, políticas de renovação e eficiência energética. Com todas as metodologias aplicadas, foram selecionados para o estudo 33 programas de financiamento e oito políticas de proteção do consumidor em diferentes países. Destes programas, doze foram analisados mais detalhadamente.

Alguns dos resultados encontrados demonstram que os esquemas que se destinam exclusivamente ao combate da PE, a maioria das medidas foi financiada a 100%. Os instrumentos financeiros mais utilizados nos programas estudados foram as subvenções, sendo a maior parte do financiamento destes programas proveniente de fundos europeus, exceto no caso da Nova Zelândia e da Austrália. No que respeita às medidas, o isolamento e a instalação de equipamentos de aquecimento e arrefecimento foram as medidas mais encontradas.

Tendo em conta as análises efetuadas e os obstáculos mencionados nas entrevistas, foram retiradas algumas conclusões. Uma abordagem de colaboração entre diferentes atores é essencial para a realização e o desenvolvimento destes regimes. Para além disso, o estabelecimento de indicadores de avaliação e uma metodologia de monitorização são também importantes para verificar o sucesso dos programas e garantir a sua transparência. Finalmente, a integração de programas de incentivo à EE com estratégias de redução de PE, e com foco em medidas de renovação profunda, é essencial para reduzir as emissões de carbono, aumentar o acesso à energia, e contribuir para um futuro mais sustentável e equitativo.

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Acronyms List

- AU – Australia
- BRANZ - Building Research Association of New Zealand
- CF - Cohesion Fund
- CO_2 – Carbon Dioxide
- E3 - Energy Efficiency of Equipment
- EC – European Commission
- EE – Energy Efficiency
- EECA - Energy Efficiency & Conservation Authority
- EED - Energy Efficiency Directive
- EEMs – Energy Efficiency Measures
- EEO - Energy Efficiency Obligation
- ELPRE - Long-Term Strategy for the Renovation of Buildings (*Estratégia de Longo Prazo para a Renovação dos Edifícios de Portugal*)
- EP – Energy Poverty
- EPAH – Energy Poverty Advisory Hub
- EPBD - Energy Performance of Buildings Directive
- EPC – Energy Performance Certificate
- EPOV - European Energy Poverty Observatory
- ERDF - European Regional Development Fund
- ESF - European Social Fund
- EU – European Union
- FP – Fuel Poverty
- FPRN - Fuel Poverty Research Network
- GHG – Greenhouse Gas
- HTR – Hard to Reach
- IEA – International Energy Agency
- IHRU - Institute for Housing and Urban Rehabilitation
- IPCC - Intergovernmental Panel on Climate Change
- KfW - Kreditanstalt für Wiederaufbau
- LIHC - Low-Income High Costs
- MEPS - Minimum Energy Performance Standards
- MSs – Member States
- NABERS - National Australian Built Environment Rating System
- NatHERS - National Home Energy Rating System
- NDC - Nationally Determined Contribution
- NECPs - National Energy and Climate Plans

- NEPP - National Energy Productivity Plan
- NZ – New Zealand
- NZEB - *Nearly Zero Energy Buildings*
- PAE+S – Sustainable Buildings (Programa *Edifícios + Sustentáveis)*
- PNAEE - National Action Plan for Energy Efficiency (*Plano Nacional de Ação para a Eficiência Energética*)
- RCCTE - Thermal Performance of Buildings Regulation (*Regulamento das Características de Comportamento Térmico dos Edifícios*)
- RNC 2050- Roadmap to Carbon Neutrality 2050 (*Roteiro para a Neutralidade Carbónica 2050*)
- RRP - Recovery and Resilience Plan
- RSECE - Regulations on Energy Performance of Buildings (*Regulamento dos Sistemas Energéticos de Climatização em Edifícios*)
- TSEE – Tariff for Electrical Energy
- UK – United Kingdom
- UN - United Nations
- UNDP - United Nations Development Programme
- UNFCCC - United Nations Framework Convention on Climate Change
- VAT – Value-Added Tax
- VE- Efficiency Voucher (*Vale Eficiência)*
- WERS - Windows Energy Rating Scheme

1 INTRODUCTION

With the Kyoto *Protocol* in 1997 and the adoption of the Paris Agreement at COP 21 in 2015, climate change has been increasingly recognised as one of the most critical and urgent issues of our time. Limiting global temperatures to below 2ºC above pre-industrial levels was a major milestone in negotiations that ultimately defined a global plan to mitigate the effects of climate change. The main objective of the Paris Agreement is to peak greenhouse gas emissions (GHG) as soon as possible and balance their emissions with their removal by sinks [1]–[3]. Energy production and consumption significantly impact climate change by contributing to CO_2 emissions. In the European Union (EU), energy production and use account for 80% of total GHG emissions. Although the building sector accounts for 40% of the final energy and 36% of emissions in the EU, with the residential sector accounting for approximately 25% of emissions, it is considered one of the sectors with the most significant potential for energy savings [1], [3].

According to the Intergovernmental Panel on Climate Change (IPCC Special Report 2018), energy efficiency (EE) and building renovation are two key points for achieving carbon neutrality while bringing many benefits, such as reducing urban pollution and reducing energy poverty (EP) for the population [1], [2].

The concept of EP[1] (i.e. fuel poverty (FP) in the UK) emerged in England in 1973 as a result of an energy crisis in which energy prices rose to levels that families could not afford. In the 1980s, the term 'fuel poverty' was established. Still, it was not until 1991 that the first official definition was established in the UK: "FP is the inability of a household to obtain adequate energy services (in the home) for 10% of its income". Today, the European Commission (EC) defines EP as "a situation where households lack access to essential energy services and products." EP occurs when energy bills represent a high percentage of consumers' income or when they must reduce their household's energy consumption to the point where it negatively affects their health and well-being. The context of the current EP in the EU is diverse, owing to the multidimensionality of drivers and regional differences. According to a Europe-wide survey conducted in 2020, 8% of the European population reported that they were unable to keep their homes adequately warm [4]–[7]. The countries in which this problem was most common were Bulgaria (27%), Lithuania (23%), Cyprus (21%), Portugal, and Greece (17%) [8].

[1] The term energy poverty is used throughout this dissertation as an example of fuel poverty. In general, the term energy poverty is used in line with the European Commission's concept. In the chapters and analyses referring to the UK, the term fuel poverty will be used, as this is the term used in British policies.

Nevertheless, many policies have been developed and implemented over the years to increase the EE of buildings and fight EP. In 2019, a Clean Energy Package was adopted for all Europeans. As part of their commitment to fighting EP, European countries have had to draw up their National Energy and Climate Plans (NECPs), integrating different measures, definitions of concepts and solutions, and methods to monitor the situation in the country. In 2020, a Recommendation on Energy Poverty was launched to support local governments on this issue, of which the Renovation Wave was an integral part. This provides a guide for appropriate indicators to measure EP in each country and to promote the exchange of best practices between Member States (MSs) [4].

The Fit for 55 package was another measure adopted in July 2021. It proposes specific actions to identify the main drivers of EP risks for consumers, such as high-energy prices, low household income, and the low EE of buildings [4].

Governments can support building renovations and develop more energy-efficient markets by adopting appropriate policy solutions. Financial and fiscal instruments play an essential role in many countries as they can help financially constrained households undertake energy renovations and remove various financial barriers that may exist. Given the low share of new buildings, renovation of existing buildings is the best solution for achieving carbon neutrality in this sector. Policies supporting EE include the Energy Performance of Buildings Directive (EPBD) (EU) 2018/844 and the revised Energy Efficiency Directive (EU) 2018/2022. EU structural and investment funds, such as the European Regional Development Fund (ERDF), European Social Fund (ESF), and Cohesion Fund (CF), are funds that support energy projects and financial instruments implemented in European countries [1], [4], [6]

New Zealand is situated in the Ring of Fire in the Pacific Ocean, where it is estimated that 25% of the country's households suffer from FP [8]. To meet this challenge, New Zealand has many natural advantages that enable it to make ambitious energy transitions. In terms of energy policies, New Zealand does not have a defined, long-term national strategy. In the May 2022 emission reduction plan, the government committed to developing an energy strategy. This strategy should be consistent with the country's vision of having a highly renewable, sustainable, and efficient energy system by 2050 that is affordable, accessible, secure, and reliable, and supports the well-being of New Zealanders [10], [11].

In terms of EE, under the Energy Efficiency and Conservation Act of 2000, EECA was established to promote and support EE, energy conservation, and the utilisation of renewable energy. Through partnerships with the private sector and the government, the EECA implements a few programmes to achieve its objectives. In addition, the government also helps promote EE through public information and behaviour change campaigns [12].

Australia is the largest country in mainland Oceania, where the energy sector plays a key role in GHG. Australia's natural advantage makes it one of the world's largest exporters of fossil fuels, resulting in high emissions. To achieve the goals of the Paris Agreement, the government has launched several plans in recent years (Powering Australia, the Safeguard Mechanism, the Regions Food Fund, the National Electric Vehicle Strategy, and the National Reconstruction Fund) [13].

EE is one of the issues addressed by the Australian policy. It is approached in terms of productivity and its function is to improve the performance of buildings, reduce consumer bills, and reduce emissions. Residential buildings have been the most energy-intensive in the country, with their energy consumption doubling since 2000. Several policies have been implemented to improve the EE of homes, particularly vulnerable homes. The trajectory for low-energy buildings provides measures to make existing buildings net-zero. Other approaches include building codes, labelling, and certification schemes, such as the Australian Building Code, Commercial Building Disclosure Program, voluntary National Australian Built Environment Rating System (NABERS), Nationwide House Energy Rating Scheme, and Your Home. All these programmes were implemented at the national level. However, as these policies are also implemented at the regional level, states such as Victoria and New South Wales have strong public support programmes [13].

Finally, the UK has been researching FP for several years and is at the forefront of developing this issue. The methodologies used to assess the concept vary across the UK, making comparisons impossible. According to recent statistics, 13% of the population in England, 25% in Scotland, 14% in Wales, and 24% in Northern Ireland are considered fuel-poor [14].

There are UK-wide policies in place to tackle these issues as well as more local policies for each country. In terms of EE, the main policies currently in place are energy company obligation, green disposal, EE in rented properties, social housing decarbonisation funds, and home upgrade schemes. For direct support to the most vulnerable households, the current programmes are Winter Fuel Payments, Cold Weather Payments, and The Warm Homes Discount. In addition to these measures, new measures were announced in early 2022 to help UK households with rising energy prices due to inflation and Ukrainian invasion [15].

This study had several specific aims:

- Understanding the energy contexts of different countries;
- Different funding landscapes;
- Characterise existing schemes and programmes focused on FP and EE;
- Analyse the effectiveness of the schemes found in and;
- Characterisation of effective and efficient models.

The main objective of this study is to explore and compare financial instruments to tackle energy poverty and/or promote energy efficiency in residential buildings in the EU, the UK, Australia, and New Zealand to understand the best features and successful cases for the design of a model scheme.

This dissertation is divided into 10 main chapters, the last of which contains the appendices. Its structure is as follows:

- The 2nd and 3rd chapters present an overview of the current issues of EP and EE;
- Chapter 4 examines the current state of energy policy in the countries studied and the types of instruments most commonly used today;
- Chapter 5 presents the methodology developed and the case studies;
- Chapter 6 presents the results obtained after applying the methodology;
- Chapter 7 presents a discussion of the results in Chapter 6;
- Chapter 8 presents guidelines for the development of a financing scheme in Portugal.
- Chapter 9 presents the conclusions, limitations of the study, and suggestions for future work.

A short article was developed and a presentation of the results obtained was made at the 8th Energy and Environmental Economics Conference [16]. The article was published in the Book of Extended Abstracts and the event was organized by the University of Aveiro. The book's DOI is: https://doi.org/10.48528/v3b3-fk78.

2 ENERGY POVERTY

2.1 Definition

EP has gained prominence in the political and academic world. It was first introduced by Isherwood and Hancock during a major economic crisis in the United Kingdom (UK) in the 1970s, followed by the oil crisis [17]–[19]. This issue had its first official definition in the UK in 1983 and was developed by Bradshaw and Hutton [20]. This concept describes the situation faced by households when more than 10 % of their income is spent on energy [21], leading to the creation of the first '10 % indicator based on utility bills [17]. Guertler [22] defines FP as "the inability of a household to afford a level of domestic energy that is considered socially and materially necessary". More recently, FP has been defined as households whose necessary energy prices are higher than the national median, placing them below the “official poverty line" [23].

As a result of these developments, the UK has taken the lead in researching the issue across Europe and has even created one of the main indicators to measure the problem: Low-Income High Costs (LIHC) [6]. In the rest of the world, the concept has become multidisciplinary as climate change, energy transition, the pandemic, and, more recently, Russia's invasion of Ukraine have led to rising energy prices and widened the spectrum of vulnerability [24], [25].

Despite a long history of international commitment, more than 1.2 thousand million people worldwide still don't have access to electricity, while another 2.8 thousand million have no choice but to use traditional biomass for cooking and heating [23]. This situation is known as EP. It is generally defined as the inability to afford socially and materially necessary levels of household energy services, which can affect health, social inclusion, environmental quality, mental well-being, and productivity [6], [17], [19], [26], [27]. This issue is at the intersection of household income, energy price and EE of household appliances [28].

In addition to this, there are other definitions for EP created by international organisations. The United Nations (UN) has defined EP as the inability of a household to achieve a socially and materially necessary level of household energy services [25]. The United Nations Development Programme (UNDP) defines it as the absence of sufficient choice in accessing adequate, affordable, reliable, high quality and environmentally and health-friendly energy services to support the economic development opportunities of communities. According to the International Energy Agency (IEA), EP is the lack of access to electricity and reliance on the traditional use of biomass for cooking and heating [29]. The European Commission (EC) defines EP as a situation where households lack access to essential energy services and products [4].

Today, despite their differences, the two terms are used interchangeably [30]. To combat this problem, the United Nations has established SDG 7 - Ensure access to affordable, reliable, sustainable, and modern energy [28]. In developed countries, the problems of EP are different. In the European Union, EP is mainly caused by low income, poor energy performance of buildings and high energy prices [6], [17], [19], [31], [32]. In addition, factors such as taxation, low investment in energy infrastructure and a lack of awareness and knowledge about EE can also play a role [33]. Climate change adds another layer of complexity, especially in winter, cold and summer [25], [27].

Compared to people who can meet their basic energy needs, the energy poor often live in inadequate housing and are more likely to fall ill [26]. The effects of EP range from respiratory and circulatory problems, social isolation, physical stress (due to lack of heat/cooling), fatigue, reduced ability to concentrate and increased mortality and morbidity due to extreme heat and cold (especially in children, the elderly, pregnant women and people with disabilities) [6], [28], [32], [34]–[37].

In the case of the EU, the countries most affected by the phenomenon are the westernmost countries and some in the south, while countries such as Sweden and Finland are the least affected [19], [33]. In this context, it is necessary to quantify the number of families in a situation of EP and design policies and monitoring measures to mitigate this phenomenon [31], [33].

These policies need to consider various parameters, such as housing quality. To this end, EE is an important policy area for improving the quality of life of the most vulnerable [26], [33].

2.2 Vulnerable groups

For policies to reach the most significant number of people experiencing EP, they need to be well-identified. Several authors are therefore working to identify more precisely which groups/people are most at risk of EP [27], [38]–[44]. Lucie Middlemiss, from the School of Earth and Environment, Sustainability Research Institute, has compiled a list of all the most vulnerable groups described in the scientific literature. According to the author, the common factor for all vulnerable groups is low income and high energy costs. Although these two events can occur separately, it is prevalent for them to occur together in a person's life [45].

Other pervasive characteristics of vulnerable groups are education and gender issues. The issue of education is related to childhood experiences, i.e. if a child grows up in a healthier and better educated family, it is natural that they will tend to consume more energy as adults. On the other hand, if a child grows up in an unhealthy, low-skilled, and poor environment, they will tend to consume less energy in the future. In terms of

gender, people in domestic and caring roles, who tend to be women, are also more likely to suffer from EP [27], [38]–[44].

In addition to these described groups, there are many others, such as unemployed adults in the household; people with low education; people from ethnic and indigenous minorities; immigrants; people who are nearing or are elderly; people with disabilities; young people and full-time students; lone parents; socially isolated people; large households and multiple occupancy households [27], [38]–[44].

2.3 Hard-to-reach

An intertwined concept gaining ground in the scientific community is 'hard to reach' energy users. In some countries, this concept may be confused with low-income households or vulnerable groups. However, this group is much more diverse and comprehensive [46]. The term HTR users is often used by social and health services, local and national governments who want to ensure that everyone has the right to a service that is intended for the general public [47]

There are various definitions of HTR users, which can often be contradictory. Rotmann [48] defined the concept based on a series of interviews conducted by the author, which resulted in a general definition of the concept: "A hard-to-reach energy user is any energy user in the residential and non-residential sectors who uses any type of energy or fuel, mobility services, and communications, and who is typically physically hard to reach, underserved, or difficult to engage or motivate in behaviour change, EE, and demand response interventions that are intended to serve our common needs."[49]

In many countries, these groups include low-income, high-income, black, Asian, indigenous or people of colour, rural residents, multi-family dwellings, tenants, people experiencing homelessness, drug and gang houses and day-care centres [47]. These different groups face different barriers to becoming HTR users. The barriers are diverse and can be attributed to a lack of access to energy services, fragmented incentives, high prices, language differences, lack of trust, cultural differences, lack of motivation or lack of appropriate policies. For example, for higher-income families, the barriers relate to a lack of motivation and disinterest, while for refugees or immigrants, the barriers are cultural, lack of trust and a language barrier [47].

To overcome these limitations, several guidelines are proposed to reach out and support these communities. Some recommendations are [46], [49]

- To increase collaboration between professionals and policymakers and to place greater emphasis on research in this area;
- Promote awareness of potential stigmas that may exist between communities;
- Creating personalised incentive programmes for different community groups;
- Promoting the work of support teams within communities.

3 Energy Efficiency

3.1 Concept

The urgency of climate change requires a rapid change in current energy consumption patterns [2]. Their production and consumption have a significant impact on atmospheric CO_2 emissions. With the United Nations Framework Conference on Climate Change (UNFCCC) at the Rio Conference in 1992, the Kyoto Protocol in 1997 and the more recent Paris Agreement in 2015, climate change has been widely recognised as one of the world's top priorities [3]. In addition to setting targets to limit the temperature to below 2ºC, the Paris Agreement also sought to implement targets to limit the temperature to 1.5ºC above industrial levels. This was to be achieved by "reaching a global peak in GHG emissions as soon as possible" and "achieving a balance between anthropogenic emissions by sources and removals by sinks in the second half of the 21st century" [3]

Building renovation is one of the most important approaches to reducing GHG [50]. The building sector is currently the largest consumer of energy, accounting for around 30-40% of total energy consumption and around 38% of GHG. Buildings alone are responsible for 40% of total energy consumption and 17.5% of emissions, with residential buildings bearing the greatest responsibility (10.9%) [51]–[53]. For this reason, retrofitting existing buildings is essential if the world is to reduce its emissions [54], [55].

This renovation should take place by increasing the EE of residential buildings [56]. EE is one of the five dimensions of the EU's Energy Union strategy, which aims to create a secure, affordable and sustainable energy system [57]–[60]. In recent years, the International Energy Agency (IEA) has demonstrated the importance of EE to its member states, which have begun to prioritise the issue in new policies [61]. Despite the broad international consensus on the implementation of EE in different countries, the quantification, interpretation, and translation of this efficiency into concrete policies is still unknown [60], resulting in low renovation rates. In most countries, renovation rates are below 1% due to the complexity of implementation [50], [62], [63].

Other EE definitions used in policy analysis are (i) thermodynamic EE, which uses a thermodynamic input and a physical output; (ii) economic thermodynamic EE, which measures output in monetary terms and input in thermodynamic units; and (iii) economic efficiency indicators, which measure both input and output in monetary terms [60]

In addition to the definitions described above, EE is directly linked to other concepts such as energy conservation and its accessibility in underdeveloped countries. In countries such as Uganda, the development of EE usually focuses on increasing energy access to the population. This is because the application of EE measures can help ensure

that the expansion of the grid, together with the production of clean energy, reduces costs for customers [64]. As for energy conservation [59], these two concepts are distinct but directly related. Both share the common goal of reducing energy consumption to conserve natural resources, improve public health and reduce GHG. The difference is that the ways to achieve this goal are different, with energy conservation taking into account habits and behaviours, and EE mostly technologies [59].

Given the importance of this issue, it is crucial to implement strategies that promote renovation in the residential sector. Its implementation is seen as a "win-win" solution, not only reducing GHG emissions and investments in energy structures, but also helping to improve the financial situation and well-being of the population, including reducing the percentage of EP in the country [2].

3.2 Motivations

Implementing energy efficiency measures (EEMs) has numerous benefits that appeal to politicians, institutions, and the public [64]. But the reasons and motivations for these different stakeholders may differ. At the political and institutional level, the need for EEMs is directly linked to the importance and impact of climate change, and to the technical and socio-economic implications of EP [59], [65]. In this context, the main concern at the policy level is to present a holistic approach to promote a just transition and thus equal access for the whole population to new energy sources and housing conditions. But when we talk about the general population, the motivations for exploring the universe of EE may be different [62].

The main motivations for people to invest in EE are comfort and energy use/price. According to the author Gonzalez-Caceres *et al.* [54], when someone wants to update their home, their main concern is the cost of the different phases of the renovation, its impact on energy consumption and on the electricity bill respectively. However, these motivations can also vary according to personal factors, activities of daily living and social factors, and the homeowner's life stage can also play a role in the decision [54], [67]. For example, younger generations tend to be more environmentally aware than older ones, so they can carry out energy renovations in their homes, even if they are not visible to the community. In contrast, in older generations, where environmental awareness is less present, reasons related to comfort and aesthetics are more important when making decisions [67].

Although the motivations for decision making may vary, it is undeniable that the implementation of these measures is linked to a number of benefits in different areas. At a macroeconomic level, the implementation of EE measures can promote the creation of direct jobs in the companies making the investments and indirect jobs throughout the supply chain [3], [19], [59], as well as increasing the demand for labour in the

construction sector [66], [68] This increases the stimulation of economic activity and promotes its recovery and growth [52], [68]. As a result, these home improvements increase the value of homes and extend the life of buildings.

Another economic and social benefit is improved public health. By implementing EE measures, the internal quality of dwellings is higher, which improves the quality of life of their occupants, resulting in fewer admissions to health centres [16], [47], [64]. Reducing the demand for fossil fuels reduces the need for energy infrastructure such as transmission lines and coal, oil or natural gas power plants, which is also an important benefit as it reduces air pollution [55].

Energy security [3], [19], lower electricity costs [51], [59], improved grid reliability [63], availability of wages for the population and improved social status are other benefits that result from implementing EEMs [64], [66].

3.3 Context

The COVID-19 pandemic and the war in Ukraine have caused economic instability and the construction sector has suffered some consequences. One of the consequences has been an increase in energy consumption in buildings, especially in the residential sub-sector. This instability has increased the urgency of energy conservation and energy transition worldwide. In the case of the pandemic, lockdowns and remote working have demonstrated the impact that EE can have on a person's quality of life and financial affairs [63].

Prior to these two major events, the world continued to progressively produce and consume energy. For example, in 2019, Australia consumed approximately 66 210 kWh of primary energy per capita (Figure 1), while producing only 9 774 kWh of electricity per capita. Globally, primary energy consumption per capita averaged 21 014 kWh, while electricity generation per capita was 3 395 kWh [53].

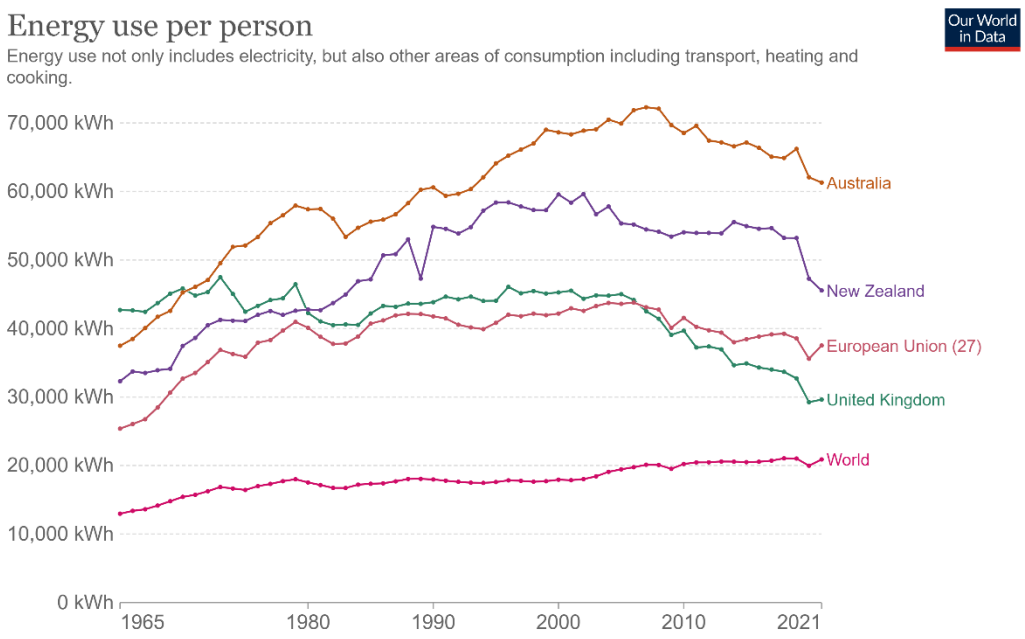


Figure 3-1 - Energy use per person in the countries in study. Source: [53]

In 2022, about 81% of the world's primary energy will still come from fossil fuels (Figure 2). The most representative renewable energy source is hydropower (6.73%), followed by wind (3.27%) [53].

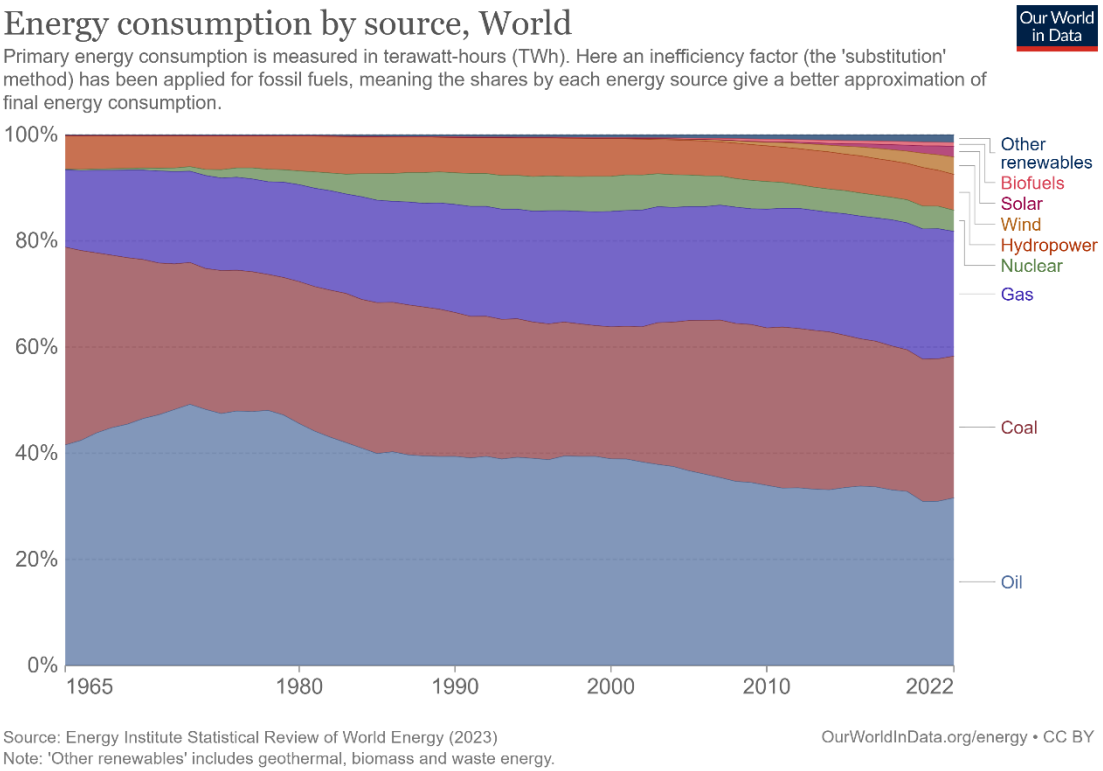


Figure 3-2 - Energy consumption by source, World. Source: [53]

According to the IEA, due to all the disruptions over the past three years, global energy-related CO_2 emissions rose by 0.9% in 2022, reaching a new high. However, this growth in emissions was lower than expected, despite many countries switching from gas to coal. Around 20% of this increase in emissions is due to energy demand for heating and cooling buildings. In 2021, the construction sector will emit around 3.01Gt of CO_2, with residential buildings accounting for 21.2% of this figure [53].

Looking at the EU, the figures are relatively different. In 2021, buildings will account for 43% of final consumption, with residential buildings alone accounting for two-thirds of this consumption. Considering these figures and all the efforts made by different countries to implement EE policies, the amount invested in building renovation has increased by about 16% compared to 2020 [55]. Despite this increase in investment, renovation is still well below the desired level.

3.4 Strategies

Several strategies can be adopted to improve the EE and quality of residential buildings. The first step is to carry out an analysis of the building stock and its main characteristics [55]. The ageing of the building stock is a normal reality for many countries, and to improve it, various strategies can be adopted, such as the use of more efficient technologies, changes in the design of existing buildings and changes in behaviour. To implement these strategies, it is necessary to create incentives to help and motivate households to improve the quality of their homes. Some strategies include financial incentives, regulation, voluntary programmes for industry or information campaigns (these instruments will be discussed later) [58].

There are two groups of technical strategies for renovating dwellings: active and passive measures. Active measures include all types of electrical (or non-electrical) equipment used for heating or cooling. Some examples are efficient windows, elimination of thermal bridging, air conditioning, lighting, or hot water production. Passive measures include everything related to the building envelope, such as building orientation, air sealing, continuous insulation, natural lighting, and natural ventilation [3], [63], [70]. The combination of these two types of measures can result in a significant reduction in energy consumption and bills for households, and a consequent increase in thermal comfort [63], [70]. Another type of measure that can be applied is smart metering. These can be used to help control energy supply and consumption, inform households about their behaviour, and encourage conservation measures [3]. Figure 3 compares current final energy consumption with the consumption set for the 2030 EE target, as set out in the Paris Agreement [59].

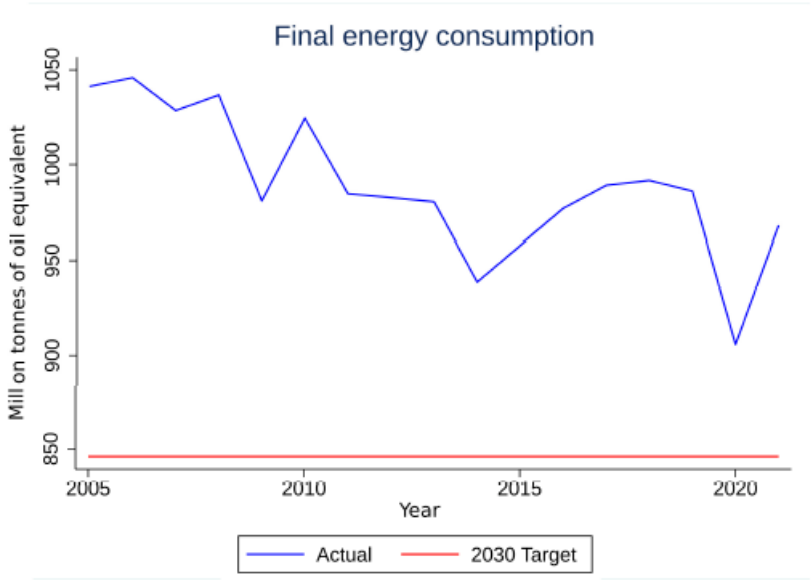


Figure 3-3 - European Union's final energy consumption with regard to 2030 goals. Source: [53]

At the behavioural level, families can take a number of measures to reduce energy consumption and maintain thermal comfort in the home. An ENACT study [71] has developed 150 tips to improve home conditions in terms of energy and water consumption. Some of these are:

- Make sure the fridge door is always tightly closed;
- Replace incandescent bulbs with LED bulbs;
- Do not leave electrical appliances on standby;
- Close blinds/doors facing south and west on hot days;
- Set the thermostat on the water heater to 49ºC.

3.5 Barriers

EE has many benefits for families and a cost-benefit ratio that has been proven by many studies. However, achieving this goal is not without its challenges [2], [3]. Currently, the actual rate of adoption of EEMs is far below the level optimised by the scientific community. This difference is known as the "energy efficiency gap" [2], [3], [54], [72]. This usually happens because EE measures are not implemented in a holistic way, resulting in greater social disparities and higher energy consumption [51].

The authors Vogel *et al.* [73] conducted a study in which they categorised 38 barriers into three decision groups: project level, sector level and context level. Eleven barriers were identified at the project level, 18 at the contextual level and eleven at the sectoral level. Table 1 shows some of the barriers identified by the authors.

Table 3-1 - Barriers to the implementation of EE measures. Source: [73]

Sector level	Weak or lacking feedback structures; Weak communication structures between companies, organizations, and academia; Lacking comprehension of system benefits; Lacking system view, leading to lost opportunities.
Project level	Lacking transparency weakens system benefits; Lacking knowledge about investment horizons, risks, and life spans; Lacking knowledge of and interest in energy related topics; Lacking knowledge of details in projects.
Contextual level	Weak national energy regulations when refurbishing buildings; Incoherent national and municipal energy regulations; Unclear incentives for the market to reach energy targets; Lack of contact areas between energy user and energy producer.

In addition to these barriers, other important barriers have been identified by other authors, such as high transaction costs [74], uncertainties about increases in property values, lack of direct financial incentives for landlords [64], [68], [72], [75], [76], fragmentation of incentives [64], [68], [72], [75], [76], evictions due to rent increases caused by renovations, political invisibility of tenants [23], energy consumer behaviour or lack of technical expertise [64], [68], [72], [75], [76].

4 ENERGY POLICIES

4.1. European Union and United Kingdom Energy Policies

In the fight against climate change, the EU has made EE in residential buildings a key issue. This sector is one of the largest energy consumers in the EU (25% of total energy consumption according to Eurostat 2018), but at the same time has the greatest potential for savings, which drives improvements [77]–[79].

Since 2002, the EU has adopted several directives on building performance, EE, and consumer protection in relation to the energy market. Each Member State has the freedom and responsibility to address these directives on its own territory by developing effective policies [6].

One of the first directives was the EPBD (2002/91/EC), which was revised in 2010 (2010/31/EC). The aim of this directive was to promote the improvement of the energy performance of buildings, considering climatic and local conditions and economic viability [80], [81]. One of the key elements of these directives is the energy performance certificate (EPC). It is referred to as "a certificate recognised by a Member State or by a legal person designated by it, which indicates the result of the calculation of the energy performance of the building or an autonomous part thereof in accordance with an approved methodology (...)" [81], [82]. The methodology is applied in different ways in each country, but all of them must take into account the following points: the actual thermal characteristics of the building, the heating and hot water installation, the air-conditioning installation, the mechanical and natural ventilation, the fixed lighting installation, the design and positioning of the building, the passive solar systems and solar shading, and the climatic conditions [81], [82]. This directive was last updated in 2018 (2018/844/EU), with the aim of accelerating the renovation of existing buildings and making them nearly zero energy buildings by 2050 [83].

Arcipowska *et al.* [84] developed a study evaluating EU policies, focusing on the quality of EPCs in the EU-28 plus Norway. The UK certificate system is presented as an example. This is a regional approach with three different schemes, one for England and Wales, one for Northern Ireland and one for Scotland. In the case of the English system, it is run by the Landmark Information Group without any government support. Only an official energy assessor can register the data on the certificates so that they become valid and can then be used when selling or renting a home [84].

Another key directive is the Energy Efficiency Directive (EED - 2012/27/EU), which amends Directives 2009/125/EC and 2010/30/EU and repeals Directives 2004/8/EC and 2006/32/EC [85]. The aim of this Directive was to establish a framework of measures to promote EE with the aim of achieving a 20% EE target by 2020. It required MSs to set an individual target and provided policy tools to help them formulate energy policies

[57]. In 2018, this directive was updated (2018/844/EU), encouraging MSs to apply minimum energy requirements to rental housing and proposing stricter guidelines. One of the recommended instruments is energy efficiency obligation (EEO) schemes, which will be discussed in a later chapter [86].

Over the years, policies have also been developed to protect energy consumers and combat EP. The first directives were Directives 2003/54/EC and 2003/55/EC, part of the second energy package [28]. These set out rules for the electricity and gas markets [87], [88]. These directives mentioned the need to protect vulnerable consumers by creating laws against power cuts and inability to pay bills [6]. These directives were later updated with the introduction of the third energy package (2009/72/EC and 2009/73/EC) [89] and for the first time made EP and vulnerable consumers explicit, leaving their definition to each MS [28], [32], [90]. They also show the importance of implementing measures to address the problem, such as the introduction of state support and public energy services. The most common forms of support in Europe are social tariffs, social rebates, and price caps. These interventions, according to Dobbins *et al.* [91] are important for solving accessibility problems in the short term, while at the same time they can complement long-term measures [92] For example, one of the most widely used is social tariffs. These allow the most vulnerable groups to access energy at more affordable prices [91]. In other words, it is available exclusively to the most vulnerable groups and it is a tariff for which these groups pay less than other customers. Another definition of this instrument is that it is designed to encourage people to use more energy in order to make their homes more energy efficient without worsening their financial situation [91]. Other common measures are energy conservation measures. These are non-financial measures that impose moratoria on disconnections for certain people and for certain periods of time. They can be divided into two broad categories: direct protective measures and other complementary measures. The direct measures are bans on disconnection. The other complementary measures are debt management and customer participation. The former refers to negotiated payment plans or financial subsidies to help pay for electricity. The purchase of prepaid meters is also a widely used technical measure where customers pay for their electricity and gas consumption in advance to manage their debt. Customer involvement is based on promoting a relationship between the energy supplier and the customer where they should communicate whenever they have doubts or questions [91].

In addition to the Third Energy Package, other initiatives have been created, such as the Vulnerable Consumers Working Group (2016) [6], which aims to support and ensure the implementation of the Third Energy Package [32], and the Energy Union (2015) [6], [93], which creates a legislative framework with a coherent approach across all policy areas [94]. At the heart of the Energy Union is the Clean Energy for All Package (2016) [95] also known as the 'Winter Package' [6], which aims to achieve a rapid energy

transition and meet the commitments made in the Paris Agreement. This package of measures aims to create a political balance between the different dimensions of the MSs by discovering synergies and efficiencies that would not exist if countries acted alone [94]. Some of the main objectives of this document are: the principle of "energy efficiency first", achieving global leadership in renewable energy, and providing a fair deal for consumers [28]. In 2016, the EC also launched the European Energy Poverty Observatory (EPOV) to combat EP. This was an initiative to support MSs in reducing their EP and its mission is to promote a change in knowledge about the state of EP in Europe and about policies and practices to reduce it. This project lasted 40 years [96], [97]. In 2021, and based on the work of EPOV, the Energy Poverty Advisory HUB was established. This initiative aims to eradicate EP and accelerate the just energy transition of European local governments. It provides various tools to guide MS and other stakeholders in implementing concrete measures, such as reports, indicators, online courses and the EPAH ATLAS, a database that presents all local and national projects and measures to combat EP [4], [97].

The Energy Union has also created the Energy and Climate Governance Regulation (2018/1999) [98]. This creates a governance mechanism based on long-term strategies - integrated national energy and climate plans covering a 10-year period (between 2021 and 2030). These plans are drawn up by the MSs themselves and must present the current situation of the country's energy system and the situation of the Energy Union dimensions (energy security; internal energy market; EE; decarbonisation; research, innovation, and competitiveness). It must also present all national objectives and the related policies and measures to achieve them [98] . Another important aspect of these plans is the obligation for MS to assess the number of households living in EP. If this number is significant, MS must present at least one indicative target to reduce the assessed number [98].

The Electricity Directive 2019 (2019/944) [99] is another piece of EU legislation. This Directive establishes common rules for the generation, transmission, distribution, storage, and supply of electricity, as well as consumer protection rules, to create truly integrated, competitive, consumer-led, flexible, fair, and transparent electricity markets in the Union [99]. The Directive also regulates relations between MSs with a view to creating an interconnected internal electricity market that strengthens the integration of electricity from renewable energy sources, free competition, and security of supply [100]. Recommendation (EU) 2020/1563 on EP was also launched in 2020. This Directive supports MSs in their efforts to combat EP. It also provides a set of indicators for national governments to assess their situation [101].

In December 2019, the EC launched the European Green Deal [102], [103]. This package of initiatives aims to put Europe on a green transition and achieve carbon neutrality by 2050 through a modern and competitive economy. It presents a holistic approach

between climate, environment, energy, transport, industry, agriculture, and sustainable finance. One of the initiatives included in this package is Fit for 55 [104]. It presents a set of measures aimed at updating European policies. The name of the initiative comes from the EU's target to reduce its net GHG by at least 55% by 2030 [105], [106]. Two of the proposals described in the package relate to EE and the energy performance of buildings [105], [106]. On EE, Fit for 55 proposes a revision of the EU Energy Efficiency Directive to reduce final energy consumption by 11.7% by 2030 (compared to 2020) [107]. Regarding the energy performance of buildings, the initiative proposes new targets to make all new buildings zero emission by 2030 and existing buildings zero emission by 2050 [106]. Another important proposal is the creation of a Social Climate Fund. This fund will contribute to achieving climate goals by tackling EP, supporting the growth of green jobs, and improving environmental performance [108].

In the EU, three quarters of buildings are energy inefficient and the annual renovation rate is only 0.4-1.2%. Therefore, in the context of COVID-19, the EC presented the Renovation Wave strategy at the end of 2020, which aims to accelerate renovation in the Union [109]. The main objective is to double the annual rate of renovation in residential and non-residential buildings by 2030 and to promote deep energy renovation, which currently accounts for only 0.2 % across Europe, as well as to reduce GHG from buildings by 60 % by 2030 [110]. In real terms, this target will lead to the renovation of 35 million buildings [111]. The strategy has three pillars: tackling EP and the worst performing buildings, improving public buildings and social infrastructure, and decarbonising heating and cooling technologies [109]. One of the reasons for low renovation rates is financial constraints. Between €150 thousand million and €275 thousand million of investment would be needed to improve the 220 million European buildings that need renovation [109]. With this in mind, the EC has created several financial instruments that can help overcome this financial barrier, especially for low-income families. Two of these instruments are The Recovery and Resilience Facility and Cohesion Policy [109]. The Recovery and Resilience Facility finances investments between February 2020 and December 2026. To receive this funding, countries must submit national recovery and resilience plans describing the investments to be made during this period and setting clear targets to be achieved [112].

The most recent policy is REPowerEU [113], [114]. This plan emerged shortly after Russia's invasion of Ukraine, when leaders asked the EC to develop policies to reduce dependence on Russian fossil fuels. In response to this request, the plan was presented in May 2022 and focuses on supporting the energy transition to clean energy. This plan is based on the implementation of the objectives of the Fit for 55 Strategy. The reforms and investments that need to be carried out in order to receive funding (implemented by the Recovery and Resilience Facility) are: improving energy infrastructure and facilities; EE in buildings; decarbonising industry; increasing the production and use of

sustainable bio-methane and hydrogen; increasing the share of renewable energy; combating EP; promoting energy demand reduction; solving internal and cross-border bottlenecks in energy transport and distribution and supporting zero emission transport; and supporting energy storage [113], [114].

Until 2020 (the date of Brexit), the UK introduced its energy laws and regulations based on European Union directives. As a member of the EU at the time, the countries that made up the UK followed all the directives. After the transition period, the UK completely abandoned European laws and established its own policies. One of the tools the UK created was the Net Zero Strategy: Build Back Greener. This document sets out policies and proposals to meet the targets in the Nationally Determined Contribution (NDC) and defines the vision for a decarbonised economy by 2050 [115]. The policy has 8 pillars, one of which is Heat & Buildings. The aim is to improve homes and non-domestic buildings so that they consume less energy to heat and are more comfortable, while reducing dependence on imported energy. A few key measures have been put in place to achieve this: the phasing out of gas boilers by 2035; the creation of programmes and funding schemes for investment in low carbon systems (Boiler Upgrade Scheme) and heat pumps (Heat Pump Ready Programme). The Heat Pump Ready Programme was launched in 2022 with the aim of supporting innovative solutions in the heat pump sector, as these are key to decarbonising homes by 2050 [116]. The programme is divided into several strands, supporting the development, and testing of solutions and methodologies for the deployment of high-density domestic heat pumps, and the development of tools, technologies, and processes to overcome barriers to the deployment of domestic heat pumps [116].

Another very popular programme in the UK is the Green Deal. This programme aimed to finance EE improvements. The programme was discontinued in 2016 after it was found that its results were below expectations. The programme used a financial mechanism called 'pay-as-you-save', which works like a loan that is paid back over the years through energy bills. Bergman & Foxon [15] carried out a study in which they conducted a series of interviews to identify the main criticisms of the programme. According to the interviewees, there are three main areas of concern. Firstly, the programme was poorly designed from the outset, which meant that bureaucracy and complexity were one of the negative factors of the programme. Another reason for the programme's failure was the lack of private investment and the higher loan interest rates than those offered outside the programme. Finally, the lack of consumer involvement was mentioned as a third factor, as the programme did not target the well-being, health, and domestic needs of households [15], [117], [118].

4.1.1 Case Study: Portugal Energy Policies

European countries have different economic, environmental, climatic, and cultural characteristics, which means that their energy behaviour is also different. Southern European countries have greater difficulties in adapting to climate change than northern countries, leading to higher energy consumption [119]. However, this is not the case in Portugal. The country has one of the lowest levels of EE in Europe, but at the same time it is one of the countries with the lowest final energy consumption per capita in the residential sector [120]. This chapter describes the main policies and instruments implemented in Portugal.

One programme is the EPC Guidelines. This programme was launched by the government to analyse the energy performance of residential buildings. It helps to clarify information on the energy performance of small dwellings and commercial units to improve the EE of these buildings. The EPC measures the EE of the building and calculates some specific characteristics of the buildings such as: heating/cooling demand, final energy consumption, assessment of refurbishment measures and others. All buildings must be audited to obtain their certificate during construction or renovation and whenever they are sold or rented out [120]. The first regulation on building performance was published in 1990 and was called the Thermal Performance of Buildings Regulation (RCCTE). This regulation aimed to impose requirements on the design of new buildings and most renovations. Eight years later, the Regulations on Energy Performance of Buildings (RSECE) were created with the aim of improving the thermal comfort of homes and indoor air quality. With the creation of the EPBD at European level in 2002, Portugal adopted Decrees 78/2006, 79/2006 and 80/2006. These decrees changed the paradigm of Portuguese buildings and energy needs by creating the Energy Certification System for Buildings and Indoor Quality (SCE 2006), the Regulations on Energy Systems for Air Conditioning (RSECE 2006) and the Regulation on Thermal Behaviour Characteristics of Buildings (RCCTE 2006). With the European revision of the EPBD in 2010, a new law was created in Portugal, Decree 118/2013, with the Building Energy Certification System (SCE), the Regulation on the Energy Performance of Residential Buildings (REH) and the Regulation on the Energy Performance of Commercial Buildings (RECS). This new certification basis has already been revised and updated several times, most recently in 2019, Decree-Law 95/2019 [121], [122].

The Portuguese Carbon Neutrality Roadmap was approved in 2019 by Council of Ministers Resolution No. 107/2019 of 1 July. The development of this document began in 2016, when Portugal made the commitment to achieve carbon neutrality by 2050. The roadmap sets out the path to achieving carbon neutrality by 2050, defining the guidelines and identifying the cost-effective options to achieve this goal, regardless of the country's

economic situation. The main success factors identified in the roadmap include EE, urban renewal, the fight against EP, the use of renewable resources, electrification and the introduction of new energy vectors such as hydrogen [123]–[125].

In 2001, the National Strategy for Climate Change was approved, together with three other documents: The National Climate Change Programme, the National Emission Allowance Allocation Plan, and the Portuguese Carbon Fund. These first documents had little political or public relevance, and it wasn't until the second half of the decade that the issue of climate change began to gain momentum. From 2004 to 2021, several versions of the National Climate Change Programme were approved, always accompanied by programmes for evaluating and monitoring the programmes and their objectives [126] . The latest PNEC was launched in 2021 and is currently considered one of the main climate and energy policy instruments for the period 2021-2030. The plan replaces the National Action Plan for Energy Efficiency (PNAEE) and the National Action Plan for Renewable Energy (PNAER) and aims to achieve the long-term goals set by Portugal in the Roadmap to Carbon Neutrality 2050 (RNC 2050). The plan presents eight strategic objectives linked to the five dimensions of the Energy Union: decarbonising the national economy; prioritising EE; strengthening the commitment to renewable energy; ensuring security of supply; promoting sustainable mobility; promoting sustainable agriculture and forestry and enhancing carbon sequestration; developing innovative industries; ensuring a fair, democratic, and cohesive transition [124], [127]. Regarding buildings, the PNEC 2030 establishes the reduction of carbon emissions and the promotion of energy renovation of the building stock, with particular attention to the implementation of *Nearly Zero Energy Buildings* (NZEB)[2]. The National Energy and Climate Plan foresees a 45-55% reduction in GHG by 2030 compared to 2005 [120].

Portugal's Recovery and Resilience Plan (RRP) was launched in 2021 and will run until 2026, with the aim of helping the country return to sustainable economic growth, ensure an exit from the energy crisis, and guarantee a resilient future through the implementation of a series of reforms and investments [128], [129]. The plan is structured around three main pillars: Resilience, Climate Transition and Digital Transition. Energy falls under the Climate Transition pillar. This dimension sets out an ambitious sustainability agenda that promotes the use of the country's resources and the development of economic sectors around the production of renewable energy. One of the components is C13. Energy Efficiency of Buildings, which includes various reforms such as the Long-Term Building Renovation Strategy, the Public Administration Resource Efficiency Programme 2030 (ECO.AP 2030) and the National Long-Term

[2] a concept that defines a building with very high energy performance, in which energy required, which is almost zero or very low, must be covered by energy from renewable sources.

Strategy to Fight Energy Poverty. Of the planned investments (610 million), 300 million are earmarked for EE in residential buildings [128], [129].

As a result of the Clean Energy Package for all Europeans and the EE Directive, Portugal launched Decree-Law 101-D/2020 and the Long-Term Strategy for the Renovation of Buildings (ELPRE) [130], [131] . This strategy sets targets for the years 2030, 2040 and 2050, compared to 2018 figures, and aims to increase the renovation of buildings, increase primary energy savings, and reduce thermal discomfort in homes by hours [121], [122]. The measures that this strategy implements correspond to interventions in the building envelope, replacing existing systems with more efficient ones, promoting the use of renewable energy, creating public and private financing programmes for renovation, and strengthening incentive policies and market monitoring [131].

The most recent strategy is the National Long-Term Strategy to Combat Energy Poverty. This strategy is established by the PNEC as one of the measures to combat EP. Some of the measures established by the strategy are support for EE actions, both for tenants and homeowners, social housing, and the Vale Eficiência (VE) programme, which will be studied in Chapter 6.2.17 [132]. This strategy has been developed together with a coordination group to monitor and evaluate it. This group is coordinated by the General Directorate of Energy and Geology, with technical support from ADENE [132]. Another programme created in this context was "1ºDireito - Programme to Support Access to Housing". This programme aims to support the promotion of housing solutions for people living in poor conditions who do not have the financial capacity to improve their situation. The programme focuses mainly on the rehabilitation and rental of buildings [133]. The programme is administered by the Institute for Housing and Urban Rehabilitation (IHRU).

In addition to these policies, in recent years the Portuguese government has also introduced policies to protect the most energy vulnerable families to combat EP. These policies are based on two main points: consumer protection and the energy saving cluster [121] . One of the country's most important measures was launched in 2010 and is called the Social Tariff. This tariff is a social support consisting of a discount on bills for low-voltage electricity and/or low-pressure natural gas. The current one came into force in 2016, Law No. 7-A/2016, which amended Decree-Law No. 138-A/2010 and Decree-Law No. 101/2011, increasing access to this service from 200 000 to 800 000 households [121], [134].

4.2 Australian Energy Policies

Ali *et al.* [135] point out in their study that Australia is considered one of the worst performing countries in terms of environmental policy. This lack of regulation has

resulted in the country's residential energy consumption accounting for 61 % of final consumption in 2021 [13]. In any case, these policies have increased and evolved since the 1980s.

The effects of the oil crisis were not felt in Australia until 1973 [136]. It was only after this date that the Australian government began to identify the main energy issues, such as energy conservation and a reasonable level of energy self-sufficiency. At this time, one of the measures was to allow energy to increase to conserve it and change behaviour [136]. During this period, various government teams were set up to deal with the energy crisis until the Energy 2000 policy was published. This document was produced in 1988 and aimed to ensure energy security, increase the export performance of the energy industry, and improve the EE of the system [136].

In the 1990s, Australia created the first National Home Energy Rating System (NatHERS) to incentivise improved energy performance. This system used rating software that understood the home's ability to maintain thermal comfort. The scale of this scheme is 0-10, with 0 being the worst rating and 10 being the best. In addition to the national government, Australian states also began to respond by creating increasingly stringent requirements for the performance of dwellings [137]. Initially, these requirements focused only on wall and ceiling insulation [137].

Around the same time, the national government also introduced Minimum Energy Performance Standards (MEPS) for electrical and gas appliances. These standards were part of another programme launched at the time, Energy Efficiency of Equipment (E3), which aimed to improve the EE of equipment and appliances in Australia [138].

After the early 2000s, several market incentive schemes for EEMs were developed. The first was the Windows Energy Rating Scheme (WERS). This scheme, launched in 2001, allows windows to be rated according to their impact on people's homes. Companies apply to the scheme to obtain these ratings from the Australian Fenestration Ranting Council [139].

Between 2003 and 2004, minimum requirements for dwellings were set out in the Building Code of Australia, which became part of the National Building Code. The aim of this incorporation of mandatory standards was to strengthen them and introduce them for all types of buildings in 2006. In the same year, the BCA revised the requirements to help reduce GHG. These requirements worked in conjunction with NatHERS [137], [139]. Today, these requirements have been updated and improved over the years [137].

In 2009, another incentive for national construction was created. The instrument is called the Energy Efficiency Homes and Solar Water Rebate and has two main components: home insulation and a solar water rebate [139].

From 2010, the frequency and diversity of EE policies in the country began to increase. In 2015, the National Energy Productivity Plan (NEPP) was adopted[140]. This

document aims to increase Australia's energy productivity by 40 % by 2030. In 2019, the Low Energy Building Pathway was created to achieve carbon neutrality in commercial and residential buildings. This strategy defines policies and timelines, but does not set specific targets [13], [141].

Finally, since 2020, the National Energy Performance Strategy has been developed by Australian ministers and provides guidance on long-term EE [13], [141]. Energy performance includes comprehensive energy management, always including EE as one of the main measures and as an essential role for the climate. In September 2022, the Australian government, under international pressure to come up with more demanding specific targets, created the Climate Change Act. It aims to reduce GHG by 43 % by 2030 and achieve carbon neutrality in all sectors by 2050. The Act requires an annual statement on future GHG targets [13]. This document is the main vehicle for the government to outline and change its approach to achieving the targets [13].

Policies to address EP in Australia are underdeveloped, with no national level policy to encourage regions to make concrete proposals. Throughout the review, the only policy found to protect consumers was the Energy Retail Code of Practice. This measure, implemented in Victoria in 2019, aims to reduce the number of energy consumers disconnected from the grid due to debt. To this end, financial assistance was provided to the most vulnerable families [142].

4.3 New Zealand Energy Policies

New Zealand has always been a country with high levels of renewable energy production, even before the Kyoto Protocol. Geothermal energy and hydroelectricity are still the main sources of electricity [12], [143]. In 2016, 85 % of electricity was generated from renewable sources [135], with the rest coming from natural gas and coal. However, as the country has developed, particularly in road transport and housing, energy consumption has increased and so have emissions [143].

To combat this trend, and with the introduction of the Paris Agreement, New Zealand committed to ambitious targets for reducing GHG. The target was a 50 % reduction from 2005 levels by 2030 (at gross level). The country has also committed to making the entire built environment carbon neutral by 2050 [12], [143]. The strategy that embodies this goal is the Climate Change Response (Zero Carbon) Amendment Act, enacted in 2019, whose predecessor was the Climate Change Response Act 2002. This was the first policy in the country to cover different policies for different sectors [143]. This new policy led to the establishment of the official New Zealand Climate Change Commission, which is charged with advising and monitoring the government on the implementation of a greener economy [12], [140]. In addition to the Commission, the Act also requires the

development of emissions budgets and emissions reduction plans, which set out how much emissions will be allowed over a given period [12].

In a country with access to so many natural resources, these targets seem achievable, but the country is still at a very early stage in implementing global policies related to climate change and the energy world [143]. All energy codes are currently virtually unchanged since the 1980s, and there are no long-term strategies, let alone sectoral strategies such as for buildings [12].

New Zealand's building stock accounts for about 22 % of final energy consumption, most of it in the residential sector. Most dwellings are very inefficient because they were built before the first minimum insulation requirements were introduced. This policy was first implemented in the country in 1978 and covered new buildings. Since its introduction it has been updated in 2000, 2008 and 2021 [12]. The New Zealand Building Code was also implemented in 1992. This was also aimed at new buildings, but was based only on the basic performance of buildings [12].

Currently, there is no mandatory certification policy in New Zealand, but there are some voluntary schemes that are working to achieve certification in residential buildings and beyond. One scheme is NABERSNZ. This programme is based on the Australian certification scheme (NABERS) and aims to help homeowners and tenants reduce their energy consumption, thereby reducing their bills and emissions. In addition to the certification policy, several schemes have been introduced since 2009 to help New Zealand families improve the insulation of their homes and replace their heating/cooling equipment. The organisation responsible for administering these schemes is the Energy Efficiency & Conservation Authority (EECA). This organisation was established in 2000 under the Energy Efficiency and Conservation Act. This Act was created to promote EE, energy conservation and the use of renewable energy sources. This strategy has been updated in recent years, the most recent of which expires in 2022 [143], [144].

4.4 Financial Instruments

Policy instruments are fundamental to improving EE in the buildings sector, as they aim to influence household behaviour [146], [147]. They can be divided into two main groups: direct and indirect. Direct instruments are means by which the government requires individuals and institutions to behave in a certain way. Indirect instruments provide incentives for individual action [147].

Several studies present different classifications for indirect instruments. Shen *et al.* [146] classify policy instruments into three groups: mandatory administrative instruments, economic incentive instruments and voluntary incentive instruments [147], [148]. In addition to this classification, the authors subdivide each into three further

typologies: i) legislation, regulations, codes, and standards; ii) subsidies, tax incentives and loans; iii) and R&D, certification and labelling, government services [147], [148]. The International Energy Agency also presents its own classification of seven categories. The categories are behavioural measures, economic instruments, information and education, policy support, regulatory instruments, research, development and implementation, and voluntary approaches Information tools are usually audits, EPCs and labels, and smart meters [149], [150]. These measures are usually taken by local and national governments to change user behaviour. Several authors have shown that some campaigns have already resulted in energy savings, but they tend to be short-lived and the effects diminish over time [148]. Of all these categories, economic incentives are usually considered to be the least effective. They usually take the form of subsidies, charges or other financial costs to the consumer or energy producer [149] . In the United States and the European Union, various instruments have already been developed to improve EE in all types of buildings through tax incentives, loans, subsidies and EEOs. Voluntary instruments, on the other hand, are more developed than economic and mandatory instruments. The United States and Australia are the countries that have made the most progress in this area [146].

However, not all these instruments are clearly effective. Methods for verifying the results once the measures have been implemented are poorly developed, which is an obstacle to analysing these policies [151]. What's more, the effectiveness of the instruments may also vary between households. In owner-occupied dwellings, where residents have more decision-making power and fewer barriers to the development of the measure, they end up implementing more EEMs than tenants [152].

In the following subchapters, some types of financial instruments (grants, tax incentives and loans) are described in detail, showing their advantages and possible limitations. In addition to the three types of instruments that will be described in detail, there are other incentives that should be mentioned because of their development in recent years, such as Energy Efficiency Obligation Schemes (EEOS), One-Stop Shops (OSS), Energy Services Agreements, Energy Efficient Mortgages and Crowdfunding. The most common of these are EEOs and OSSs. EEOs are instruments adopted by the government to incentivise the market to invest in EE. This incentive is realised through obligations imposed on companies, i.e. they have to prove that they have achieved energy savings through activities that promote or improve EE conditions for end users [1], [153]. OSSs are independent consultants provided by the government or by organisations related to the energy sector that offer comprehensive services [1]. They are usually defined as advisory tools that help consumers to access services and financing instruments and guide them through the different stages of renovating their homes or commercial buildings [153].

4.4.1 Grants

Subsidies and grants are economic instruments that are widely used internationally because of their simplicity. They are usually used by government when the market is unable to achieve the optimal level of investment on its own [1], [154], [155]. Their function is also to help households and firms overcome the initial cost barrier to investment, as they may not be able to do so on their own [1], [59]. In other words, it helps with the purchase and installation of equipment, as well as with advice and certification [1]. Ultimately, this aid promotes a temporary change in the market. In the case of EE, these financial instruments are also important to promote awareness and confidence in projects and to improve cash flow [1]. They can usually cover part or all these investments [59].

Take-up rates for this type of programme are high, often attracting beneficiaries who would carry out interventions without the help of subsidies (free riders). The intensity with which they are applied can vary according to different parameters. For example, in the case of energy performance, more ambitious projects can usually be better funded. Target groups can also be a parameter that varies the intensity. The most energy vulnerable groups usually have access to higher subsidies. Household income can also influence the intensity of funding [153].

However, although this type of instrument has the capacity to move the market and help people to finance themselves, it is not considered to be the most beneficial and has some limitations. Subsidies are usually based on limited financial resources and do not provide a permanent and sustainable solution [1], [153]. In addition, these instruments can increase investment and installation costs. This increases the need for governments to increase incentives (making them even more limited) and to create complementary programmes. Another limitation is the rebound effect. These policies can lead to large-scale purchases of more efficient individual appliances, which will increase energy consumption. In addition, according to Bertoldi *et al.* [1], this purchase may prevent more deep interventions in households with positive effects. Other barriers include investment cycles, bureaucracy, and lack of trust in installers and technologies [153], [156]. The existence of 'free riders' also prevents good monitoring of programmes, which is another limitation of the instruments [153]. An example of a programme with these limitations is the Spanish Renove programme. This programme finances more efficient dishwashers and has led to some rebound effects, welfare losses and a significant deficit in the public budget [72].

4.4.2 Loans

Loans are forms of financing that can provide liquidity and direct access to capital, which can be relevant for high EE investments [1], [153]. Some loan conditions for the

purchase of EE equipment and projects are long repayment periods, low or zero interest rates and grace periods [1], [154]. To implement these loans, many governments are appointing state-owned investment banks to support the energy transition and fill the financing gap for households and/or businesses. One example is the Kreditanstalt für Wiederaufbau (KfW) in Germany. This development bank finances one of the country's most prominent programmes and plays a key role in the country's economic and environmental sectors [1]. However, there is insufficient evidence on the effectiveness of this type of financial instrument [156].

There are different types of loans that can be used for EEMs. The types are Traditional loan schemes and subsidised loans; Performance Contract Billing Repayment Model loans; Tax Based Repayment Model loans; Electricity Bill Repayment Model loans. Traditional and subsidised loans are the most common in the EU. This type of loan occurs when the interest rate charged on the loan is lower than the commercial rate charged by financial institutions[153], [156]. They are developed through partnerships between the government and banks, where the government provides financial support to the bank, which in turn offers these loans to clients. They often appear as complementary instrument to subsidies. France, Belgium, and Croatia are examples of countries with zero interest rates for the most vulnerable groups [153].

Another type is loans with a repayment model based on the electricity bill. This instrument is used and studied in the United States. It is a mechanism that reduces upfront cost barriers by linking the repayment of investments to the electricity bill, allowing customers to reduce the cost of EE investments over time. They can be useful for small businesses, single and multi-family homes, and rental properties. The instrument can be divided into two sub-groups: on-bill loans and on-bill tariffs. The difference between the two groups is that on-bill loans must be repaid when ownership is transferred. In contrast, on-bill tariffs tie the obligation to the property, allowing repayments to be transferred to the next tenant or buyer [153].

4.4.3 Tax Incentives

Fiscal instruments are the most widely used policy instrument worldwide to promote EEMs [153], [156]. heir use can be beneficial in reducing investment costs for households and businesses through lower taxes. These incentives can be provided through exemptions, deductions, tax rebates, property taxes and VAT [1], [156]. As with loans, these instruments are often combined with subsidies. For the government, these instruments can be cheaper and more effective than subsidies, but like all instruments, they have their limitations [1], [153]. Tax incentives may not be as far-reaching as other instruments. This is because not all households have access to the same level of taxation [154].

The most common type of tax incentive is an income tax credit or deduction. These are usually used to introduce new technologies [1], [153]. Another type of tax incentive that is widely used is value-added tax (VAT) reductions. These incentivise EEMs by offering lower VAT rates on the cost of purchasing and installing EE products and materials. This cost reduction attempts to influence consumer choice [1], [153]. Unlike subsidies, these instruments are generally received after the intervention has been carried out and do not solve the problem of upfront costs [154].

An example of VAT reductions is the Portuguese case. Between October 2022 and December 2023, the Portuguese government reduced the VAT on electricity from 13% to 6% for the consumption component for the first 100 kWh per month, and for large families, the VAT reduction applied to the first 150 kWh per month. This measure was aimed at the entire population with a contracted power of 6.9 kVA [157].

5 METHODOLOGY

This study analyses and compares financial instruments aimed at addressing energy poverty and promoting energy efficiency in residential buildings across multiple countries worldwide to draw conclusions about the most effective features and success stories, with the goal of designing a model scheme. After this analysis, a general framework of a financing program was created, considering the flaws and strengths detected. Eight main steps were followed to achieve these objectives, as shown in Figure 4. In this chapter, in addition to the different phases of the methodology, the countries under study and some of their characteristics will also be presented in subchapter 5.1.

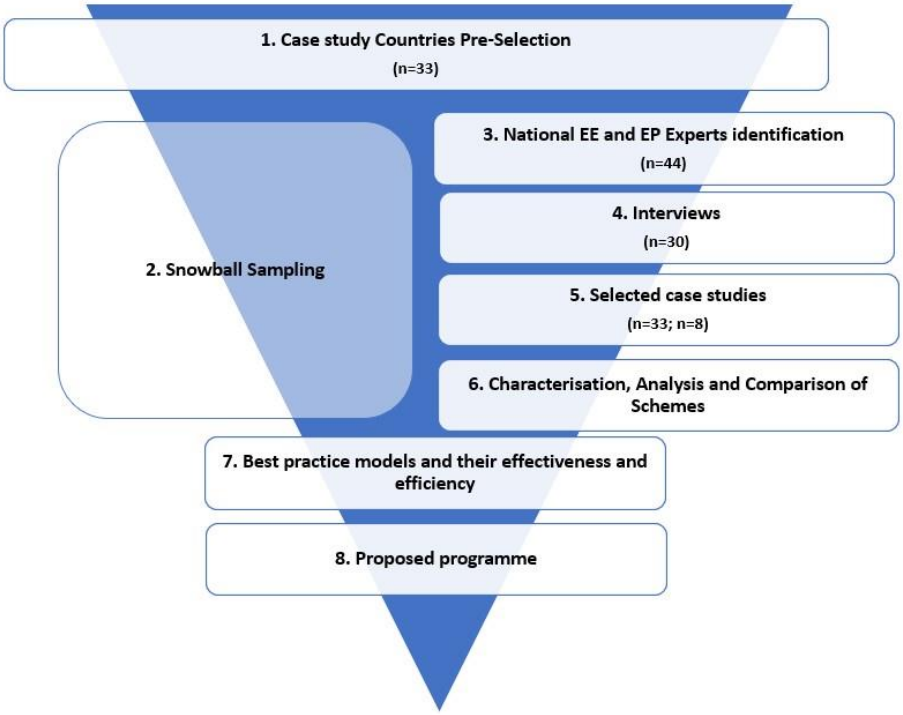


Figure 5-1 - Methodology used throughout the present study.

First phase:

At this stage, different countries were selected to be analysed in the dissertation. This selection was based on the world's high-income economies that we wanted to study: the European Union (17 countries), the United Kingdom (four countries), Australia and New Zealand (Figure 5). The choice of Australia and New Zealand was based on cultural similarities and the long-standing relations these countries have with the EU, especially the UK. When examining issues such as EE and EP, these countries show progress in the transition to renewable energy and prioritising energy efficiency. They also demonstrated unique efforts to combat EP and promote sustainability, offering valuable insights into the global energy landscape [158], [159]. In contrast, countries such as the United States and China, while important players in the global energy sector, face

distinct challenges stemming from their larger scales, different energy mixes and divergent policy approaches.

Figure 5-2 - Countries under study (EU, UK, Australia, and New Zealand) and number of funding schemes per country.

Second phase:

The research methodologies used in this dissertation include the desktop research method in grey literature, scientific literature, and information collected from the experts interviewed (Phase 4). In addition to this methodology, a combination of database search techniques and snowball techniques [160] was used, as in the study conducted by J.E. Fontecha *et al.* [161]. This method is used when the desired sample is not easily accessible, as it is an intentional data-collection method. This method was used to gather additional information on the financing programmes and energy policies of these countries [162]. The online databases used for this part of the methodology included Google Scholar, Web of Science, and Scopus. The grey literature was mainly obtained from various government platforms, ministries, and non-governmental organisations in different countries.

Third phase:

At this stage, experts were selected. Initially, 23 experts were selected (21 from the EU and one each from New Zealand and Australia) (Table A 1). Then, as many interviews were not answered, an additional 21 experts were selected, with a total of 44 experts chosen. The criteria for this selection took into account the speciality of experts (energy retrofit, EE, and EP), the countries and their areas of work, and their presence in different international research groups focusing on EP, such as the Fuel Poverty Research Network (FPRN) and the EPAH.

Fourth Phase:

This was the phase in which interviews were conducted. The selected experts were contacted by email, where they were presented with the topic of the dissertation and a

request for an interview about the funding schemes in their country, focusing on both EP and EE. The questions asked in the interviews were:

- " What schemes exist in X? And do you know how they work, or can you provide a website or report with this information? Would it be possible for you to give me some specific information about the schemes, such as how they work and how effective they are."
- "Are they targeted specifically at vulnerable consumers? How do the schemes identify them?"
- "What do you think could be done better to improve the results of the existing schemes in your country?"

In the end, a total of 44 interviews were sent out and thirty responses were obtained. It is important to emphasise that, in the interviews, it was stated that the data would be treated anonymously to guarantee the confidentiality of the sources. The interviews focused on the views and challenges of national funding schemes from experts, and it was not necessary to identify them specifically.

Fifth phase:

At this stage, all the information provided in the expert interviews was analysed and reviewed to select the financial schemes to be analysed. Two criteria were considered for this selection: programmes implemented after 2016, which may or may not be currently running, and availability of information in English, Portuguese, or Spanish. A total of 33 building renovation financing schemes were selected (Figure 5), and eight financing policies protected the most vulnerable consumers.

Sixth phase:

At this stage, the selected EE and/or EP financing schemes and consumer protection measures chosen through the interviews were studied and characterised. Regulations and important documents concerning the rules and structure of the programmes were analysed, and the most relevant information extracted for the analysis was the total budget of the programme, the type of scheme, the target group, the types of buildings targeted, the years of implementation, the geographical scale, the EEMs and their financing schemes, failures, and the costs and benefits. The information on EEMs has been adjusted and grouped to make it simpler and easier to understand (Table 2). Regarding consumer protection instruments, the information collected consisted of the eligibility criteria for support, the amount of funding, how it is offered to individuals, and the format for applying for this support (whether it is automatic and the responsibility of an organisation to identify vulnerable people or whether they apply themselves).

Table 5-1 - Types of use of the interventions analysed in the funding schemes.

Intervention Use Types	Details
Insulation	Roof insulation Walls insulation Floor insulation Draught-proofing Humidity
Windows	
Solar protection	
Doors	Front doors Gates
Heating or/and Cooling equipment	Geothermal energy Connection to a heating network Heat pumps Air conditioning Space heating and/or cooling Biomass in thermal installations Pellet burner Wood burner Central heating system
Domestic water systems	Heat pumps Biomass boilers Solar thermal solutions Water collectors
Electricity production	Wind or hydro turbines Batteries PV panels
Ventilation	Recuperation systems Mechanical Ventilation
Lighting installation	
Water efficiency solutions	Water saving measures
Other measures	Elevators Electric vehicles Electric cooking
Energy Services	Audits Certification Projects Building Energy Rating (BER) Advices Home project and assessment Network costs
Monitoring systems	Building automation systems
Structure measures	Anti-seismic measures Removal of architectural barriers Bioclimatic architecture solutions

Seventh Phase:

Twelve countries were selected for a more in-depth and detailed analysis, with a view to comparing and identifying shortcomings, good practices and their effectiveness and how they can serve as an example for other countries. The selection was made taking into account the amount of information found, the language of the documents analysed and the ease of access to more relevant information, such as the evaluation and monitoring of funding schemes, even though in some cases this information is still not well communicated.

Eighth Phase:

In the last phase of the dissertation, with the analysis carried out and the positive and negative examples found, a proposal was made for financing schemes to promote EE in housing and simultaneously combat EP. For the development of this programme, the focus on Portugal is justified by the pressing need to revitalise the ageing housing stock, promote EE, and reduce the country's EP levels. In addition, the financing of these measures in the country today is still below the desired level, which calls for a study to promote the correct formalisation of these political and financial measures. This proposal was made considering the Portuguese scenario, but it can be adapted to any country, always taking into account its main concerns and priorities.

5.1 Case Studies

5.1.1 European Union

The European Union is an economic and political union currently made up of 27 countries. It was founded shortly after the Second World War with the aim of promoting economic cooperation between countries and avoiding conflict. In 1958, the European Economic Community was established with the initial cooperation of six countries: Belgium, France, Germany, Italy, Luxembourg, and the Netherlands. Over the years, with the accession of 22 other countries, what began as a purely economic union became an organisation with several areas of intervention (climate, energy, environment, and health) [163].

The organisation is located on the European continent with a population of 4447.7 million people and a territory of more than 4 million km^2. The largest country is France, and the smallest is Malta [164].

The EU's building stock is quite old and inefficient. Approximately 60 percent of all existing residential buildings are now over 50 years old, indicating that they were constructed prior to the implementation of the first thermal regulations in 1970. Only countries such as Cyprus and Spain have a significant number of newer buildings. The

annual growth rate of new buildings in Europe is less than 1% on average; therefore, the impact of new energy-efficient buildings is limited and regulatory measures on their energy performance are not sufficient to reach the 2030 targets [165]. It's also important to note that almost 75% of all existing buildings are energy inefficient [166]. In 2014, there were 17.6 thousand million square metres of residential floor space. Almost three-quarters of this space is in the six largest European countries: France, Spain, Italy, the UK, Germany, and Poland.

Furthermore, most of this residential space is occupied by single-family houses, in contrast to countries such as Belgium, Italy, France, Denmark and Spain, where most of the residential space is characterised by apartment buildings [167]. In most European countries (27 out of 27), around 70% of dwellings are owner-occupied. This information is important when we think about housing renovation, as it is easier to achieve if the owners carry it out themselves[167].

According to the European Commission, the level of renovation is very low. For total renovation, the average for the 27 European countries is 1% per year [163], with Bulgaria having the highest percentage (10.85%) and Spain the lowest (0.82%). When it comes to deep renovation, the figures are less significant. The average for the 27 countries was 0.2% per year, with Cyprus, Italy and Spain having the highest percentages [168], [169].

This shows that the level of EE in the different countries is still lower than desired, and, given current energy prices, EP is still at risk of increasing. This is particularly true in southern European countries, where buildings have relatively lower energy performance than in northern and central countries[169]. The building sector currently accounts for about 40 % of total final energy in the EU, with the residential sector accounting for about two-thirds of this share. In terms of emissions, the sector is responsible for 36 % of GHG [169]. To reduce these figures, the EU currently needs to reduce its primary energy consumption by 11.7 % by 2030 [170] compared to 2020 levels. To this end, various renovation measures are being implemented, which are also intended to help combat EP. Currently, 6.9% of EU residents say they are unable to keep their homes comfortable in winter [169].

5.1.1.1 Portugal

Portugal is a country on the European continent, located on the Iberian Peninsula, with an area of approximately 92 226 km^2. It has a population of 10.3 million. Its climate is predominantly temperate, except for a small region in the southern interior, which has a steppe and oceanic climate. The average annual temperature varies between 8ºC in winter and 22ºC in summer [168].

In terms of Portugal's building stock, around 98% of existing buildings are currently residential, of which 70 % are owner-occupied. Most of the buildings were constructed before the 1980s, before the first energy performance regulations were introduced. Final

energy consumption over the last decade has ranged from 16.7% to 18.3%. The distribution of this consumption in dwellings by energy source shows that electricity is the most used source (46.4%), followed by biomass (18.4%) and natural gas (12.4%) [168], [169].

In terms of EE of buildings, the Portuguese building stock is inefficient, with 75% of residential buildings having an EE class below C. In addition, about 29% of residential buildings need renovation and 1.6% are in serious disrepair [168]. Palma *et al.* [169] carried out a study which showed that 71.7 thousand million euros are needed to improve the thermal performance of the housing stock to nZEB standards [169]. Another study carried out by Palma *et al.* [172] showed that to build a path towards decarbonising buildings, four objectives are needed: eliminating energy consumption from fossil fuels, reducing energy consumption from biomass, increasing energy consumption from renewable sources, and increasing the EE of equipment in homes. Achieving these goals would require an investment of €28.4 million, considering all energy uses such as space heating, domestic hot water, cooking, and lighting [172].

As far as EP is concerned, there is currently a definition proposed in the draft strategy, which was in public consultation between 20/01/2023 and 03/03/2023. The definition states that "inability or difficulty in obtaining an adequate level of essential energy services, due to a combination of various factors such as income, energy performance of the dwelling, and energy prices" [69]. According to the European Commission, 16.4 per cent of the Portuguese population have difficulty keeping their homes warm. [8] The strategy itself presents indicators for gauging EP levels. According to the strategy, 24.4% of the population lives in dwellings with problems with leaks, damp, or rotten elements and 1.2 million households had an energy bill representing +10% of their total income[69].

5.1.2 United Kingdom

The UK left the EU at the end of 2020 as a result of Brexit. This country is in the northern part of Europe. The island is known as Great Britain and consists of England, Scotland, Wales, and Northern Ireland. It covers an area of 243 610 square kilometres and has a population of 67.1 million. Most dwellings (57%) were built before 1965, and around 80% are in urban areas, with 63% of dwellings privately owned [14]. As a result, the UK building stock is one of the least efficient and highest GHG emitting compared to other European countries [169]. Of the four countries that make up the island, Wales has the worst efficiency due to its high proportion of older buildings (around 27% were built before 1919) [14]. The type of housing found in the UK is very characteristic of the country. The most common type of dwelling is the terraced house, especially in England

and Wales, followed by the semi-detached house with 25% and the terraced house with 20%.

When analysing EP in the region, this name changes to FP in all statistical data and is analysed separately between the four countries. Table 3 shows the percentage of households in FP in each country [14].

Table 5-2 - FP levels in the different countries of the United Kingdom. Source: [14]

Country	% of households in EP in 2021
England	13.4 %
Scotland	24.6%
Wales	14%
Northern Ireland	24%

5.1.3 Australia

Australia is one of Oceania's countries, yet it is considered one of the largest countries in the world. It is in the Southern Hemisphere between the Pacific and Indian Oceans. A member of the Commonwealth, it is divided into six states and two large continental territories. The capital is Canberra, in the north. The largest and most populous city is Sydney, on the country's south-east coast. The whole country covers an area of 7 741 km^2 and has a population of 26 268 359 [174], [175].

There are about 8.8 million residential, commercial, and industrial buildings throughout the country. The majority of these (96.1%) are dwellings and 58% of these were built before 1981. New energy performance requirements were introduced at that time, and although the Australian Register of Building Characteristics is not very up-to-date, it is known that buildings are not very efficient and waste a lot of energy [176]. Australian government records show that residential buildings are responsible for 24 % of energy consumption and more than 10 % of GHG [177]. It the same time, only 1-2% of buildings are renovated each year, so new solutions and measures are needed to reduce residential energy consumption [176].

As mentioned above, this inefficiency of buildings also impacts the level of EP in the country. Nance [178] estimates that 2-14% of Australians live in EP [178].

5.1.4 New Zealand

New Zealand is a Pacific Ocean country covering more than 268 km^2. The country is divided into two main islands (the North Island and the South Island). The capital is Wellington, the second largest city in New Zealand. It currently has 4 928 015 inhabitants and, like Australia, is a member of the Commonwealth [179].

Approximately 70 per cent of New Zealand's housing stock is residential in nature. These are generally known as low-rise timber multi-dwelling buildings and were mostly built between 1941 and 1976 [180]. The country's building stock is inefficient. The Building Research Association of New Zealand (BRANZ) conducted a study which concluded that New Zealand homes tend to have very inefficient heating systems, resulting in very high energy consumption [179]. In 2018, 51 per cent of dwellings were privately owned, and 12% of the final consumption went to residential buildings [179], [180].

The definition and monitoring strategy for FP in New Zealand is still being developed by the government, but it is currently estimated that 25 % of the population is fuel-poor [10]. One definition that already exists and is often used synonymously is "Energy Hardship". This concept is broader than FP and is defined as the opposite end of a continuum of energy well-being, that is, energy deprivation occurs when individuals, families, and whānau are unable to obtain adequate energy services to support their well-being in their home or kāinga.

6 FINANCIAL INSTRUMENTS

This chapter details various financial instruments for EE and EP implemented by different countries in the European Union, the U.K., New Zealand, and Australia. Chapter 6 will be divided into two types of financial measures. The first are energy consumer protection measures, and the latter are home renovation schemes used by different countries to help households implement building renovation measures.

6.1 Consumer Protection Measures

Secure electricity supply is fundamental to life in modern society. Rising prices and the process of market liberalisation are the two factors that have led to the need to examine how vulnerable customer groups are protected [181]. One measure widely practised by governments worldwide in recent years has been the launch of financial support. COVID-19 and the Ukrainian war are two main factors behind the exponential price rise, which has led governments to increase the number of policies to protect consumers. One of the measures implemented in Portugal was "*Bilha Solidária*"[182]. This support ends in 2023 and aims to support families with an electricity supply contract who are beneficiaries of the social electricity tariff (TSEE) or one of the minimum social benefits. The support is intended for the purchase of bottled liquefied petroleum gas (LPG) and amounts to 10€ per bottle, with a limit of one unit per calendar month and beneficiary. It is paid by the parish councils acting on behalf of the "Fundo Ambiental" [182]. In Spain, a "Bono Social Térmico" programme was launched in 2019. This is a subsidy to compensate for heating and water heating costs. Beneficiaries of this support were individuals who were beneficiaries of the "*Bono Social Eletrico*" on 31 December of the previous year. Support is provided through a single annual payment and is calculated by considering the beneficiary's degree of vulnerability and climate zone. The average payment was €90 (updated in 2021). Energy-supply companies make payments [183].

This subchapter will analyse the second question from the interviews (Phase 5 of the methodology). Several experts expressly indicated what financial support existed for vulnerable energy consumers in their countries. This indication and the grey and academic literature led to a more detailed analysis of the support (Table 4). Specifically, eight financial measures were indicated in Portugal, Spain, Italy, France, New Zealand, the UK, Cyprus, and Greece.

The different measures analysed show that there are some similarities between them. In most measures, the beneficiary must receive other social support, such as unemployment or having a large family. The other identified way of eligibility access to support is through family income, as seen in the UK and French measures. The New Zealand Winter Energy Payment Programme and the Warm Home Discount Scheme are

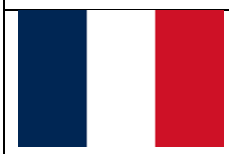
two programmes that provide support for paying electricity bills, but only during the winter months.

This support is provided in two main ways: a direct discount on the bill or a reimbursement. The Portuguese, Spanish, Italian, U.K., and Greek programmes operate as direct bill discounts. In other words, families identified as the most vulnerable have access to the discount when they pay their bills. In the New Zealand and French programmes, this support is provided through an additional monthly payment so that beneficiaries pay the bill without a discount but have access to an additional monthly subsidy from the government. An exception is the measure applied in Cyprus. Here, as in the Portuguese programme, eligible beneficiaries receive a discount on their bill. The main difference is that this discount is then repaid through a surcharge on other consumers who are not eligible.

In the other countries surveyed, vulnerable groups do not receive specific help paying for electricity. According to the experts, Bulgaria, Slovenia, Croatia, and Lithuania do not have any measures limited to helping families in EP. They receive support through the more general social assistance programmes, which, compared to the other programmes examined above, are the ones that provide eligibility for help with paying for electricity. Targeted aid for the new heating season has existed in Bulgaria since the 2000s. It functions as financial support for heating homes during winter (November-March). The support is aimed at different vulnerable groups, which have received different amounts of support until now. The geographical scale on which the support is implemented is national, and the budget comes from the government [6]. This support was updated in November 2022, supporting a further 50 000 households with 300 leva (€153) of aid [184].

Table 6-1 - Financial support for the most vulnerable groups.

 *Tarifa Social de Energia*	This social support came into force on 1 July 2016, with the amendments to Decree-Law 138-A/2010 and Decree-Law 101/2011 made by Law 7-A/2016 of 30 March. This support takes the form of a discount on the tariff for access to the low-voltage electricity and/or low-pressure natural gas networks, which constitutes the final price charged to the electricity and/or natural gas consumer. Access to this support is through an automatic mechanism that identifies potential beneficiaries. To be eligible, they must be in receipt of other social assistance, such as Family Allowance, Unemployment Benefit or Jobseeker's Allowance [134], [185], [186]. The application of this social support is financed through the holders of ordinary regime electricity generating centres, in proportion to the installed power of each generating centre, and also by all-natural gas customers, in proportion to the energy consumed, to be passed on in the tariffs for access to the networks [187], [188].

 *Bono Social de Electricidad*	This social support was created by Article 10 of Royal Decree-Law 18/2022 of 18 October and is intended to provide a social subsidy for electricity to low-income families particularly affected by the energy crisis. To access this support, the beneficiary must apply directly to one of the reference suppliers. Beneficiaries must be in receipt of some form of social assistance, such as Minimum Living Income, social security pensioner or large family certificate [189] . The application of this social support is financed by energy supply companies [190].
 Power and gas social bonus	The social bonus is a discount on the bill granted by the government and operated by the Energy, Networks and Environment Regulatory Authority to guarantee savings on energy and natural gas costs for families in a situation of economic and physical hardship. To qualify for the subsidy, one member of the family must submit a declaration of their economic situation and have an electricity or gas supply contract with a domestic tariff [191]. The application of this social support is financed through energy supply companies [192].
 Energy vouchers	French vouchers are a way of helping families pay their household electricity bills. The vouchers have a maximum value of €277, depending on household income [193]. The implementation of this social support is financed from the French state budget [194].
 Winter Energy Payment	This support is an extra monthly payment to help cover the cost of heating your home during the winter months. Registration for this support is not carried out by the beneficiary, but is automatic. To be eligible for this support, the beneficiary must already have access to other support, such as: Sole Parent Support, Supported Living Payment or Jobseeker Support. The payment amount is a maximum of $31 per week [195]. The implementation of this social support is financed from the new Zealand's state budget [196].
 Warm Home Discount Scheme	The support consists of a one-off discount of £150 on an energy bill for the winter months. To receive the support, individuals must apply and are eligible if they receive the guarantee credit element of Guarantee Credit element of Pension Credit or have a low income and high energy costs. The application of this social support is financed through energy supply companies [197].
 Special electricity tariff	The support has been offered to vulnerable consumers since 2006 and is financed by a surcharge on the electricity bills of all other consumers. The programme doesn't define exact profiles, leaving some households living in EP ineligible for support. [32], [198].
 Social Domestic Tariff	This support is a discounted domestic electricity tariff offered by all electricity suppliers to vulnerable consumers. Beneficiaries are low-income families, parents with three vulnerable children, the long-term unemployed, people with disabilities and people requiring life support. The support is limited to the electricity consumed at the beneficiary's main residence, as declared in their annual tax return. The application for support must be made by the beneficiary. The application of this social support is financed from the by the supplier companies [199].

6.2 Retrofit Schemes for Energy Poverty and Energy Efficiency

The first question in the interview aimed to identify whether the main financing programmes for residential renovations focused directly on energy poverty. In this subchapter, we analyse most of the programmes collected and indicated by experts. The excluded programmes, as mentioned in Chapter 5, were not mentioned because of the difficulty in accessing information.

6.2.1 Australia

6.2.1.1 Solar Homes Program

In recent years, the Australian government successfully increased the number of homes with rooftop solar panels. By January 2022, more than 3 million homes would have installed these energy production systems. This was achieved by launching the Solar Homes Program. This programme was launched in all Australian regions, and each regional government was responsible for administering it. An example used in this description is the Victorian programme [200]

The Solar Homes Programme (Table B 1- Appendix B) was launched in the Victoria region in 2018 and works as a rebate and a loan, depending on the typology. Its state budget is over $42 million (€24.9 million) [201], [202]. The programme aims to help families in Victoria install solar panels, an efficient water-heating system, and a solar battery by overcoming initial financial barriers. Several requirements must be met for applicants to be eligible. The four most general requirements are that applicants must be owners-occupied of an existing dwelling or a dwelling under construction, that the owners have a combined household taxable income of less than $180 000 per annum, that they have not previously received assistance for the installation of solar panels or water heating systems, and that the dwelling is valued at less than $3 million [203], [204].

To purchase the system and receive financial assistance, materials and suppliers must be selected from the official programme list [200], [203], [204]. Once the application's eligibility has been confirmed, the beneficiary will be informed whether they are eligible for the loan. This eligibility is the result of an initial rebate application. For a loan to be an option, the total value of the scheme must be more than $2 800, with a maximum loan amount of $1 400. The rebate amount is updated monthly but remains between $1 400 and $1 800. It is important to note that the loan scheme is available only for the purchase of solar panels [203], [205], [206].

In the case of water-heating systems, such as solar water heaters and heat pumps, only the discount option is available. This option is also not available for houses under construction or for replacing equipment less than three years of age. The rebate for this

type of equipment is paid directly to the supplier, and the beneficiary is responsible for paying the balance. The rebate value is updated monthly and is approximately $1 000 [204], [206], [207]

For solar batteries, the beneficiary is also only entitled to a maximum rebate of $2 950 and, unlike the previous typologies, those applying for this typology cannot have previously received support from the programme. In addition, batteries installed before July 1, 2019, were not accepted [200], [206], [208].

In addition to these typologies, this programme has special sections with special rules for solar rebates for rental properties, community housing and the Virtual Power Plant (VPP) pilot programme [126]. The latter allows recipients of solar batteries to share their stored clean energy with the grid, enabling others to use renewable energy. Thus, energy-producing households receive reduced energy bills and energy-sharing payments [209].

6.2.2 Austria

6.2.2.1 „raus aus Öl und Gas" für Private 2021/2022

This programme promotes the replacement of fossil fuel heating systems with more environmentally friendly technologies in the residential sector. The programme then focuses on EEMs and has been implemented nationwide. The Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation, and Technology is responsible for this programme, which has a budget of €940 million for renovating private buildings and businesses [210], [211].

The programme (Table B 2- Appendix B) is open to (co-)owners, authorised builders, or tenants of a single-family or multi-family house or apartment block; building owners or their official representatives (e.g., condominium management) [210], [211].

In addition to installation and design costs, the following typologies are eligible [210], [211]:

- Connection to climate-friendly local heating;
- Connection to high-efficiency local heating;
- Wood-fired central heating;
- Heat pump;
- Solar thermal collectors.

Financing for the above types is up to a maximum of €7 500, with a bonus of €1 500 if a solar collector system is installed and a bonus of €2 000 euros if gas heating is entirely replaced by a more renewable energy source. This payment is made only once the equipment installation has been completed [210], [211].

6.2.3 Belgium

6.2.3.1 Primes énergie - Régime 2015-2019

At the federal level, the Belgian government has limited powers in the field of environmental policy. Therefore, all programmes implemented in the country are at the regional level [212]–[214].

The Primes énergie - Regime 2015-2019 (Table B 3- Appendix B) is a retrofitting programme that focuses on EEMs in the Walloon region to improve the energy performance of a dwelling. The value of the subsidy can increase depending on the socio-economic position of the applicant [212]–[214].

Anyone whose household income is less than €97 7000, who is at least 18 years old, who owns and lives in the dwelling applied for, or who makes it available to a family member or for social housing, is eligible for the scheme. As for the dwelling, it is only eligible if it is located in the Walloon Region and if it was first used as a dwelling more than 20 years ago [212]–[214]. The eligible typologies are [212]–[214]:

- Roof insulation:
  - The subsidy is between 6€ and 15€/m^2, with a maximum of 150 m^2.
- Wall insulation:
  - The funding is between 6€-25€/m^2, with a maximum of 150 m^2.
- Floor insulation:
  - The subsidy is 10€/m^2, with a maximum of 150 m^2.
- Installation of heating and/or hot water systems;
  - In this measure, the funding is based on the type of equipment installed. The base value is between 200€ and 1 750€.
- Energy audit:
  - The subsidy is 220€.

As mentioned above, the amount of the subsidy is calculated taking into account the total income of the household. If a household's income is less than or equal to €23 000, the grant will be multiplied by three. In the case of a household with an income between €23 000 and €32 700, the basic amount is multiplied by the double. These brackets exist up to the maximum household income allowed, which is €97 700, where the support value is only the basic value. Moreover, these values can be increased if multiple measures are implemented simultaneously [212]–[214].

6.2.4 Bulgaria

6.2.4.1 Energy Efficiency of Multi-Family Residential Buildings National Programme

The Bulgarian (Table B 4- Appendix B) was established to ensure the best living conditions for the inhabitants of these buildings through EEMs. In addition to creating

more modern and comfortable dwellings, the programme aims to reduce energy consumption and associated energy costs [215], [216].

The programme focuses on EEMs at the national level, and the programme was open between 2015 and 2016. Its operation is based on a decentralised model. This means that more than 265 municipalities are responsible for the evaluation process of the submitted applications, and they are also responsible for the process of renovating the dwellings, which must be carried out by contractors according to the country's public procurement laws [215], [216].

The Ministry of Finance, the Ministry of Regional Development and Public Works (the main coordinator), the Bulgarian Development Bank, municipalities and local governments were involved in coordinating the programme. The initial investment was €1 billion, and this figure may have increased with the number of applications [215], [216].

As the name implies, buildings eligible for this programme are multi-family dwellings built before 26 April 1999, with three or more floors and more than six individual flats. The target group is the general population. To apply, the residents of the buildings must form a community of owners in which at least 70% of the members are in favour of the renovation.

Eligible activities are [215], [216]:

- Refurbishment works identified as mandatory for the building in the technical audit.
- Renovation of common areas of multi-family buildings (roof, facade, staircase, etc.).
- The implementation of EEMs prescribed as necessary for the building in an EE audit.

All these activities are financed by a 100% subsidy.

6.2.5 Croatia

6.2.5.1 Programmeuklanjanja energetskog siromaštva

With the implementation of the Recovery and Resilience Mechanism through the Croatian Plan, funds have been made available for implementing the Programme to Combat Energy Poverty, which includes the introduction of renewable energy sources in residential buildings for the period up to 2025. A total of HRK 150 million (€174.8 million) will be provided by the Recovery and Resilience Mechanism and HRK 205 million (€238.9 million) from the state budget based on joint and several compensations for vulnerable energy consumers [217].

The programme is implemented at the national level (Table B 5 - Appendix B), with the Ministry of Spatial Planning, Construction and State Property deciding which dwellings are eligible. The criteria for this decision is the development index of the region. If the index is lower than the national average, the municipalities are informed, and a 100% incentive is granted for renovation projects. After this analysis, all buildings that are in a very bad state of disrepair and whose tenants have a low income are signalled for the programme. Given the above, the beneficiaries of this programme are all the tenants of the buildings selected by the programme who are in a situation of EP [217].

6.2.5.2 Programa energetske obnove višestambenih zgrada

The aim of the programme (Table B 5 - Appendix B) is to increase the EE of existing multi-family buildings, to reduce energy consumption and CO_2 emissions into the atmosphere, to reduce monthly costs for energy producers, to reduce EP, to increase the value of real estate, and to increase the safety and resistance to fire and earthquakes of existing family houses. The scale of the programme is, therefore, national, focusing on the worst EPC buildings, which represent 34% of the total. The total budget of this programme until 2030 is HRK 63 million (€73.4 million), and the Ministry of Spatial Planning, Construction and State Property is responsible for its management [217].

The beneficiaries of this programme are the general population if they are owners or co-owners of the dwelling that is to be renovated. Once the programme has been launched by the Ministry, the applicant must decide which measure to apply to the dwelling, considering all the minimum requirements for its installation. Once the decision has been made, the contractor must install the measure, followed by a final energy audit to ensure correct installation [217].

The programme presents two groups of retrofits. Integral retrofits combine the installation of several efficiency measures, necessarily including one relating to the building envelope. The funding rate for this type of renovation is up to 60% of the eligible costs, and all types of buildings are eligible for this type of renovation, regardless of their energy class. The maximum eligible cost for this group cannot exceed HRK 1 500 (€1 748) per m^2 of gross building area. In the case of deep renovation, the aim is to reduce energy consumption by 50% per year, so the subsidy rate is 80% of the eligible costs. For this type of measure, the maximum allowable cost cannot exceed HRK 2 500 (€2 913) per m^2 of gross building area [217].

In addition to the works necessary for the implementation of the measures themselves, such as project preparation and management, installation, and works necessary to ensure the efficiency of the measure in the building and anti-seismic measures, the following typologies are eligible for the present programme [217] (Table 5).

Table 6-2 - EEMs and their maximum amount eligible in Croatia. Source: [217].

EEMS	Eligible maximum
Insulation of the outer shell	Maximum HRK 280/m^2
Replacement of window frames and related solar protection	Maximum HRK 515/kW
Thermal energy source for space heating and/or hot water preparation	Maximum HRK 5 290/kW
Ventilation	Max. 2 735 kW
Heating units - radiators	Maximum HRK 1 775/kW
Solar collectors	Maximum HRK 5 000 per m^2
Photovoltaic system	Maximum HRK 7500/KWp
Indoor lighting	Maximum HRK 100/m^2
Electricity storage	Maximum HRK 5 000/kWh

6.2.6 Cyprus

6.2.6.1 Grand Schemes for Energy Efficiency and Renewable Energy Sources

The implementation of Grand Schemes for Energy Efficiency and Renewable Energy Sources (Table B 6- Appendix B) is part of the Cyprus Recovery and Resilience Plan, specifically, the policy axis for a rapid transition to a green economy [218], [219].

The programme aims to provide financial resources to encourage the implementation of EEMs in existing residential buildings. At the same time, the programme aims to combat EP by creating an exclusive category for vulnerable consumers [218], [219].

The budget for this programme is around €70 million and is funded by the European Union's Recovery and Resilience Mechanism. Coordination is the responsibility of the Directorate-General of Development, a group within the Ministry of Finance [218], [219].

The programme is implemented at the national level, that is, in all areas controlled by the Republic of Cyprus, and focuses on EEMs and combating EP. Through this programme, the government aims to reduce the primary energy consumption of subsidised housing by 30% [218], [219].

There are four main areas of intervention in terms of how the programme works. In all of them, payment is made after the intervention, except in the sub-programme for the most vulnerable, where the subsidy is paid directly to the supplier [218], [219].

The entire non-legal population can apply for the programme, provided that the measures are carried out in a dwelling with residential use and that the electricity bill is presented as proof of domestic use. There is another requirement for this application. The dwellings must have their building permits submitted before 21.12.2017 or 01.01.2017, depending on the measure. All the installed appliances must be new [218], [219].

The vulnerable consumers eligible to participate are those who receive some form of social support from the government or have some form of health disability [218], [219].

Applicants can only submit one application for the whole programme, except for vulnerable consumers, who can submit additional applications in the other sections and those in their own section [218], [219].

The different investment categories are divided into thermal insulation measures and installation of photovoltaic panels [218], [219]:

- Category 1: Thermal insulation of the roof
- Category 2: Thermal insulation of the roof combined with the installation of a photovoltaic system
- Category 3A: Installation of a photovoltaic system (General Category)
- Category 3B: Installation of a photovoltaic system in the homes of vulnerable electricity consumers

As each programme has its eligibility requirements, the funding amounts are also different, as presented in (Table 6).

Table 6-3 - Types of use of the interventions analysed in the funding schemes.

Categories	Subsidy
Category 1	45% on eligible expenditure; Maximum subsidy: €2 250
Category 2	Roof insulation: 55% on eligible expenditure; Maximum subsidy: €2 750 PV system: €450 per kW installed Maximum subsidy: €1 800 **Total maximum: €4 800**
Category 3A	€375 per kW installed Maximum subsidy: €1 500
Category 3B	€1 000 per kW Maximum subsidy: €5 000

In these financing figures, the cost of the equipment, installation and fees are also included in the financing [219].

6.2.7 England

6.2.7.1 The Boiler Upgrade Scheme

The Boiler Upgrade Scheme (Table B 7- Appendix B) supports the decarbonisation of heat in buildings. The scheme provides upfront capital grants to support the installation of heat pumps and biomass boilers in homes in England and Wales. The scheme is administered by Ofgem (Office of Gas and Electricity Markets), and the Department for

Business, Energy and Industrial Strategy is responsible for the legislation. The scale of the scheme is national, so the whole population of England can take part in the programme if they want to improve their homes with efficiency measures. The budget is £450 million, and the programme runs from 2022 to 2025 [220]–[222].

The programme is open to domestic and non-domestic properties in England and Wales. Social housing or households already receiving government support to purchase a heat pump or biomass boiler are not eligible. New build properties are eligible if they are majority owner-occupied and have never been owned by a company or organisation [220]–[222].

The application process for the scheme starts with the choice of installer. For the EEM to be eligible for the scheme, the installer must be certified by the Microgeneration Certification Service (MCS). This installer is the person who takes care of the whole application process, reducing the workload for the homeowner [220]–[222].

Funding from this programme is only available for the purchase of air-source heat pumps, ground source heat pumps and biomass boilers. There are also some requirements that the installation of this equipment must meet, such as being commissioned by 1 April 2022, being able to meet the energy needs of the dwelling, replacing existing fossil fuels, and meeting specific technical standards, such as minimum energy efficiency requirements. Biomass boilers can only be installed in rural areas and in properties not connected to the gas grid, and cannot be installed in eligible self-build properties [220]–[222].

The amounts of funding available through the grant scheme are [220]–[222]:

- £5 000 (€5 827) towards the cost and installation of an air source heat pump;
- £5 000 (€5 827) towards the cost and installation of a biomass boiler;
- £6 000 (€6 992) towards the cost and installation of a ground source heat pump, including water source heat pumps.

6.2.8 France

6.2.8.1 Eco-prêt à taux Zéro

Between July 6 and October 25, 2007, the *Grenelle de l'environnement* brought together various local authorities, social partners, and NGOs with Nicolas Sarkozy's government. During these meetings, various environmental issues were discussed and the "*Eco-prêt à taux Zéro*" programme was approved in the 2009 Finance Act.

This programme allows homeowners to receive an interest-free loan of up to 30 000 euros for energy-saving renovations [223], [224]

Eco-prêt à taux Zéro (Table B 8 - Appendix B) is under the responsibility and specific management of the Ministry of the State and the Ministry of Ecology, Energy,

Sustainable Development, and Town and Country Planning, and its financing is carried out by all French banks that have signed a contract with the State. The programme focuses on EE and is implemented at the national level [223], [225]

The programme has three parts: "Individual", "Condominiums, and "Exterior". The aim is to finance energy-saving works and possible costs arising from these works to make the dwelling more energy efficient, more comfortable, and with lower GHG [223].

In general, all dwellings at the national level are eligible (both on the mainland and in the rest of the territory outside the mainland), and the dwellings must have been completed two years before the application. Condominiums are also eligible. Beneficiaries must be owners of main or rented dwellings and owner-occupied flats [223], [225].

Funding covers, within the maximum limits, the supply and installation of new works, works inextricably linked to the works, project management costs (architect), and any insurance costs for the client [223].

Interventions should be selected to achieve the best possible results in terms of efficiency. The programme, therefore, recommends that an energy audit be carried out and that the work then be carried out by qualified professionals on the list of "*Reconnus garants de l'environnement (RGE)"* [224].

The works usually carried out include thermal insulation of the roof, walls facing outwards, thermal insulation of windows, insulation of lower floors, installation, or replacement of heating or hot water, installation of heating using a renewable energy source, and installation of hot water using a renewable energy source [223].

In addition to these measures, there are also measures intended exclusively for the *Éco-prêt à taux zéro en outre-mer*. This works similarly to continental loans, but the work requirements differ [223].

If interventions are carried out on the advice of an energy audit, some criteria must be ensured, such as achieving a reduction in energy consumption of at least 35% of the initial consumption [223].

Depending on the type of intervention, a bank can lend up to €50 000 interest-free for a maximum period of 20 years [223]. Financing can vary according to specific criteria [223]:

- If the homeowner conducts only one measure, the maximum loan is €15 000 ;
- If the homeowner conducts the two measures, the maximum loan is €25 000;
- The implementation of three or more measures entitles a loan of €30 000;
- Completion of the "Total Energy Improvement" option entitles you to an ecological loan worth €50 000;
- Completing the non-collective sanitation option entitles you to a maximum loan of €10 000;

- Finally, the maximum amount of an eco-loan linked to the "*Habiter Mieux"* programme is set at €20 000.

The funding amounts for the other programme may vary slightly, but they are subject to the same criteria [223].

6.2.8.2 MaPrimeRénov'

The *MaPrimeRénov'* programme (Table B 8 - Appendix B) allows the financing of energy renovation measures calculated based on household income and the energy savings achieved after the measures have been carried out [226].

This financing programme is managed by *France Renóv*, a French public service for housing renovation, supported by the state and managed by the National Housing Agency [227]. At the time of its launch, the programme's focus was on EP, financing only families with modest incomes. However, following the COVID-19 pandemic, *MaPrimeRénov'* has been extended to all French households applying for assistance [228], with a total budget of €2.5 thousand million for 2023 [229].

All families living in the country and owning, renting, or owning an apartment built more than 15 years ago are eligible for the programme. In the case of owner-occupied dwellings, only work in common areas is eligible. Owner-occupiers can renovate up to three rented dwellings [228], [230].

Financing subsidises the purchase and installation costs of equipment and services to improve the EE of dwellings. Examples include window insulation, wall and roof insulation, equipment or materials to protect glazed or opaque walls against solar radiation in overseas departments, high-efficiency boilers, wood or other biomass heating and/or hot water systems, solar thermal heating and/or hot water systems, heat pumps, equipment or connection costs to heating or cooling networks powered by renewable energy sources, cost of removing fuel tanks, and dual-flow mechanical ventilation systems [228], [230].

The grant must be applied before the work is carried out and paid once the work has been completed. For low-income families, this amount may be paid in advance.

In the case of low-income families, the subsidy covers the total cost of renovation work, which results in energy savings of at least 35% of the initial energy consumption. The grant covers up to 35% or 50% of the cost of work (excluding taxes and duties). For families with an average income or higher (equal to or greater than €29 148), the package will finance work, resulting in savings of 55%. An energy audit is required for these renovations to be eligible [228].

6.2.9 Germany

6.2.9.1 Bundesförderung für effiziente Gebäude (BEG)

BEG (Table B 9 - Appendix B) is a funding programme to promote EE and renewable energy in the building sector. The programme is divided into three sub-programmes: federal funding for efficient buildings–residential buildings (BEG WG), federal funding for efficient buildings, non-residential buildings (BEG NWG), and federal funding for efficient buildings (BEG EM) [231].

The programme for individual measures is financed by the BAFA, while the BEG WG and BEG NWG are coordinated by the KfW and are special programmes for municipal loans and funding [231]. The programme has a budget of €2.5 thousand million and focuses on EE and its implementation at the national level [232].

Each sub-programme has its own rules and beneficiaries, so this analysis focuses only on the programme for individual measures and measures for residential buildings.

For the BEG EM and BEG WG, eligible applicants are all investors, such as homeowners, companies, contractors, NGOs, and municipalities, who intend to carry out measures in non-residential buildings or residential buildings [233], [234].

The financial support granted for this programme must be at least €2 000, which is the amount calculated considering the percentage allocated to each eligible measure [234].

In the programme BEG EM, the following typologies are considered eligible: insulation of the building envelope, replacement of windows, external doors and gates, solar thermal protection, air conditioning systems, "Efficient smart home" systems, solar systems, heat pumps, and building connections to heating systems [234].

In addition to the material costs associated with the typologies above, the programme also finances the expenses related to labour and other measures required to install equipment. In addition, the amounts related to the planning and supervision of the work were also considered [233], [234].

The funding for residential buildings in the BEG EM were limited to €60 000 per residential unit or up to €600 000 per residential building. Regarding technical planning and construction supervision costs, the limit is €5 000 for single-family houses and €2 000 per flat for multi-family dwellings with three or more flats (with a maximum of €20 000 per building) [234].

Unlike the BEG EM programme, financing is provided in the BEG WG program, considering the EE standards of an efficient house. These standards are organised according to classes, which are achieved when at least 65% of a house's energy consumption is supplied by renewable energy. For the house to reach these renewable energy production values, some of the measures eligible for this programme are thermal insulation of walls, roofs, and floors, renovation or first installation of windows/doors,

renovation of the building's heating system, installation and renovation of the ventilation system, and energy storage and optimisation [233].

For these interventions, the maximum subsidy value is limited to €150 000 if the highest value of renewable energy production in the building is achieved. At the subsidy calculation level, the EE standards are again considered, with a maximum subsidy of 20% [233].

This funding is available to applicants in different ways. In the BEG EM programme, funding is provided through a nonrepayable investment grant. In the case of the BEG WG programme, funding is provided through a share-based payment in the form of a loan [233], [234].

In addition, for each typology, funding was calculated considering a specific percentage, as shown in the table below (Table 7). All these percentages can be increased by considering specific bonuses [234].

Table 6-4 - Financing by intervention measure under the BEG Programme.

Measures	Percentage of funding
Insulation of the building envelope	15%
Plant Engineering	15%
Heat generation equipment	Maximum of 25%
Heating optimisation	15%

In general, eligible costs are the costs, including VAT, of the entire intervention borne by the applicant if the intervention has been carried out by a specialised company. If the intervention was performed by the applicant, only the materials were eligible [233], [234].

6.2.10 Greece

6.2.10.1 Exikonomo-Autonomo

The *Exikonomo-Autonomous* Programme (Table B 10 - Appendix B) is a programme that consists of promoting EEMs in the building sector. Its aim is to reduce the energy demand and fossil fuel consumption. This programme is financed by the European Regional Development Fund (ERDF) and national funds, and has a budget of €900 million. It provides incentives in the form of grants (direct aid) and loans (*Excoionmo II Fund*), with an interest subsidy. It is available at the national level and focuses primarily on EE [235], [236].

The scheme applies to buildings with a building permit or other legal documents, which are the main residences whose owners meet certain income criteria. The scheme includes five categories of incentives, with beneficiaries classified according to their

income. These incentives are between 35-65%, and these percentages can be increased to consider some fees and premiums [235], [236].

There are three types of applications. One refers to individual apartments or single-family houses, and the other two typologies (Types A and B) refer to applications for multifamily buildings. Type A refers to individual applications with common and uncommon interventions in dwellings, whereas type B refers to applications for interventions in common areas of buildings [235], [236].

For these dwellings to be eligible, they must exist legally, not be a dwelling in demolition conditions, and be used as the main residence. Additionally, the dwelling must have an energy performance rating of C or lower. Only persons with the right to full, partial, or beneficial ownership of an eligible dwelling can participate in the search for candidates [235], [236].

Once an application is approved, the applicant's home must undergo an energy audit. This audit identifies measures needed to improve the EE of dwellings. After the work has been completed, further inspection must be conducted to ensure the effectiveness of the measures [235], [236].

Only the following categories of measures are eligible under this programme [235], [236]:

- Window replacement;
- Installation/upgrading of thermal insulation
- Heating/cooling system upgrade
- ZNX system using renewable energy sources (RES)
- Other savings - self-sufficiency measures (photovoltaic, smart home, lift upgrade, etc.)

In addition to these measures, other costs are financed, such as the costs of the two energy audits, the costs of the project consultant, and the studies required for the implementation of the project [235], [236].

All houses also had the maximum eligible budget. Detached houses, flats, and type A applications have a maximum value of €48 500 and type B applications have a maximum value of €76 270 [235], [236].

6.2.11 Ireland

6.2.11.1 Better Energy Warmer Homes Scheme (BEWHS)

The Better Energy Warmer Homes Scheme (Table B 11- Appendix B) is a renovation programme designed to provide energy-efficiency improvements to low-income households throughout the country. The scheme was launched in 2002 as part of the Sustainable Energy Ireland's (SEI) low-income housing programme to support the

development and implementation of a national action plan to tackle FP. In 2011, the programme was rebranded to its current name. Since 2002, the scheme has supported over 143 000 free upgrades [237]–[239]. The scheme was coordinated by the Sustainable Energy Authority of Ireland (SEAI) and the total for all the residential and community energy upgrade schemes is €513 million [240].

Only owner-occupier households in the scheme that are beneficiaries of a social welfare programme for low-income households are included. In addition, only eligible dwellings built before 2006 were included; as of February 2022, priority will be given to dwellings built before 1993 [237], [238], [241].

The scheme comprises four main stages. First, the owner applies the scheme, and the SEAI analyses the application and decides whether to accept it. If the application is accepted as eligible, the SEAI allocates the property for a survey by a surveyor selected by SEAI. The surveyor will decide what work needs to be done on the property, and this document must be accepted by the applicant. Once all the paperwork has been completed, SEAI approves a contractor to carry out the work, and payment is made directly to the company, which means that the applicant is not charged anything [237].

The renovation measures covered by the scheme were divided into two groups: primary and secondary. The main measures include ventilation, pumping of the bonded bead cavity wall insulation, loft insulation, and external wall insulation. Secondary measures included heating systems and windows. This measure is recommended only by the SEAI if one of the main measures is recommended [242]. Once all the work has been completed, all the dwellings will be energy rated, and some may be inspected to ensure that the work is up to the standard [242].

6.2.11.2 Better Energy Homes Scheme (BEH)

The Better Energy Homes Scheme (Table B 11- Appendix B) was launched in 2009 following a successful regional pilot in 2008. It is administered by the SEAI and supports households that do not qualify for the preview scheme. The main aim of the scheme is to provide grants to homeowners who wish to invest in EEMs, which are the main focus of EE improvements in the country [243]–[245]. By 2016, the scheme had supported more than 160 000 retrofits, which was insufficient to meet the 20% energy demand target [245].

To qualify for grants, certain requirements must be met. The applicant must be the owner of a property built and occupied before 2011 (for insulation and heating control systems) or before 2021 (for heat pumps and renewable systems). In addition, a contractor must be selected from the SEAI registered list, the work must be carried out according to the standards required by the SEAI, and the building must be energy rated after the work has been carried out [246], [247].

In this scheme, unlike BEWHS, the applicants must manage the entire application. They must decide which type of measure they want to carry out and select the contractor from the SEAI list. When the work is completed, the grant is paid directly to the energy partner and this value is deducted from the costs to be paid by the applicant [246], [247].

The measures covered by the scheme include loft insulation, wall insulation, heating control upgrades, solar thermal solutions, solar PV panels, heat-pump systems, and BER. Applicants can apply for a maximum of four of these measures, and the grant for this measure increases over time, with new amounts announced for each energy upgrade on February 8, 2022. The grant that each applicant would receive depended on the dwelling type [246], [247]. Table 8 shows the grant values for each measure, and for apartments and detached houses.

Table 6-5 - Funding by intervention measure under the BEH Programme. Source:[247].

Measure		Grant value
Attic insulation	Apartment	€800
	Detached house	€1 500
Cavity wall insulation	Apartment	€700
	Detached house	€1 700
Wall insulation – internal dry lining	Apartment	€1 500
	Detached house	€4 500
Wall insulation - external	Apartment	€3 000
	Detached house	€8 000
Heat pumps systems (water to water)	Apartment	€4 500
	House	€6 500
Heat pumps systems (air to air)	All types of home	€3 500
Heating control upgrade		€700
Solar water heating		€1 200
Solar PV panels		€2 400
BER		€50

6.2.11.3 National Home Energy Upgrade Scheme

The National Home Energy Upgrade Scheme (Table B 11 - Appendix B) was launched in 2022 by the Irish Minister for the Environment. The aim of the scheme, like the BEH, is to provide grants and contractors to improve the EE of the applicants' homes. At the end of the study, an EE rating of B2 or above was achieved. The administrator of this scheme is the SEAI, which focuses on EE at the national level [248], [249]

The application process of this scheme is similar to that of the BEH process. Here, the applicant must manage all stages of the process, bearing in mind that the measures must increase the EE rating of the appliance to at least B2 [248].

To be eligible for this scheme, the person must be the owner of a property built and occupied before 2011, have a home with a BER of B3 or below, and use a SEAI-registered company to manage the work process [248]. The measures covered by this scheme are Loft insulation, Rafter insulation, Wall insulation, Floor insulation, Heating controls, Solar thermal solution (solar hot water), PV solar panels, Heat pump systems and central heating systems for heat pumps, New windows, New external doors, Mechanical ventilation, Air tightness, Home Energy Audit and Project management.

Table 9 presents the grant values for each measure. Like the BER, these values vary according to the dwelling type of the applicant [248].

Table 6-6 - Funding per intervention measure in the National Home Energy Upgrade Scheme. Source: [248]

Measure		Grant value
Attic insulation	Apartment	€800
	Detached house	€1 500
Rafter insulation	Apartment	€1 500
	Detached house	€3 000
Cavity wall insulation	Apartment	€700
	Detached house	€1 700
Wall insulation – internal dry lining	Apartment	€1 500
	Detached house	€4 500
Wall insulation - external	Apartment	€3 000
	Detached house	€8 000
Floor insulation	All types of homes	€3 500
Heat pumps systems (water to water)	Apartment	€4 500
	House	€6 500
Heat pumps systems (air to air)	All types of home	€3 500
Central heating system for heat pump	Apartment	€1 000
	House	€2 000
Heating control upgrade	All types of home	€700
Solar water heating	All types of home	€1 200
Solar PV panels	All types of home	€2 400
New windows	Apartment	€1 500
	Detached house	€4 000
New external doors	All types of houses	€800 per door
Mechanical ventilation	All types of houses	€1 500
Air tightness	All type of houses	€1 000
Home energy Assessment	All types of houses	€350
Project management	Apartment	€800
	Detached house	€2 000

These grants are paid directly to the companies, which means that the applicant only must pay an outstanding amount [248].

6.2.12 Italy

6.2.12.1 Eco-bonus

The Ecobonus programme (Table B 12 - Appendix B) was launched in 2007 with the aim of promoting the renovation of Italian housing. The beneficiaries of the programme are natural persons who incur expenses for the implementation of the measures set out in the programme. In other words, the entire Italian population has access to this programme, regardless of their income and housing situation [165], [250], [251].

The types of interventions covered by Ecobonus include window replacement, solar shading, biomass boilers, condensing boilers, heat pumps, hybrid boilers, solar collectors, interventions in the common parts of multifamily buildings, and seismic interventions. The funding amounts for this programme have changed over the years. In the year the programme was launched, beneficiaries were offered 55% of the total eligible expenditure. This was later increased to 65-85% of the costs, and now, with the introduction of Superbonus, the funding amounts have changed again to between 50-90% [165], [250]–[252].

Since its introduction, Ecobonus has supported more than 4.5 million measures, provided more than 46 thousand million euros, and reduced energy consumption by 19 000 GWh/year. Replacing air conditioners has been the most important intervention since 2007 [165], [250].

6.2.12.2 Superbonus 110%

The Superbonus Programme (Table B 12 - Appendix B), established by Legislative Decree 34/2020, runs from the beginning of 2020 to December 31, 2025. The programme is managed by the Italian Ministry of Economic Development and the National Agency for New Technologies, Energy and Sustainable Economic Development. It costs around €105 thousand million and focuses on EE [253]–[255].

The Superbonus provides a 110% reduction in funding for works aimed at improving the EE of existing buildings and/or their resistance to seismic activity, except for manor houses, villas, and castles that are not open to the public [253], [254]

Eligible activities must take place in common areas of buildings and in independent units (with one or more entrances to the outside of the dwelling) in a multifamily building. Dwellings that do not have an EPCs because they are under construction are also eligible, provided that at the end of the works, which must include thermal insulation, they achieve an energy class A [253], [254].

Until December 31, 2023, the tax deduction was within the maximum amount promised (110%), but to benefit from the deduction, 30% of the works must be completed

by December 30, 2022, and 60% by June 30, 2023. From the end of 2023, deductions are expected to be reduced to a minimum of 65% of the expenditure incurred by 2025. These payments can be divided into four equal annual instalments [253], [254].

The programme includes several types of interventions, which can be divided into two main groups: 'driving' and 'towing'. Driving interventions can provide the greatest improvements in thermal comfort and building structures. The interventions include the application of thermal insulation to the opaque building envelope, replacement of the existing air conditioning system by centralised heating, cooling, and/or hot water supply systems, and application of anti-seismic interventions [253], [254]. The Superbonus is also available for town-planning measures, provided they are applied in conjunction with the measures described above. The eligible measures are the EEMs covered by the Ecobonus, the removal of architectural barriers to facilitate the mobility of people with disabilities or those over 65 years of age, the installation of infrastructure for charging electric vehicles, the installation of solar photovoltaic systems, and the installation of storage systems integrated with solar photovoltaic systems [253], [254]

The funding amounts must be calculated considering certain limits per typology [253], [254] In the case of thermal insulation, the maximum limits are:

- 50 000 for single-family dwellings or independent units in multi-family dwellings;
- 40 000 multiplied by the number of individual units making up the multifamily dwelling if it consists of two to eight units;
- 30 000 multiplied by the number of individual units making up the multifamily building if it consists of more than eight units.

For the intervention "Replacement of winter air conditioning in common areas", the value of these interventions must consider the following limitations [253], [254]:

- 20 000 multiplied by the number of units in the building, up to eight;
- 15 000 multiplied by the number of units in the building, if more than eight units.
- In the case of single-family houses or individual units in multi-family houses, the amount of financing cannot exceed €30 000.

In the case of secondary or "additional" interventions, the calculation of financing is limited. The amount of financing for the installation of photovoltaic solar panels and storage systems has the following limits [253], [254]:

- 48 000 euros per unit and 2 400 euros per kWh of rated power;
- 48 000 euros, and in any case 1 000 euros for each kWh of storage capacity;

Individuals eligible for this programme are homeowners or co-owners of dwellings, condominiums, and socially useful non-profit organisations [253], [254]

6.2.13 Lithuania

6.2.13.1 Daugiabucių namų atnaujinimo (modernizavimo) programa

The modernization programme of multi-apartment buildings (Table B 13 - Appendix B) was launched in 2004. Over the years, many changes have been made until the final format has been achieved. The main objective of this programme was to increase the EE of multi-family buildings and to ensure that the heating costs and loan payments did not exceed the heating costs before renovation. The scheme is administered by the Housing Energy Efficiency Agency, a Lithuanian public agency established in 2001 and funded by the government. The programme operates nationally and focuses on EE and EP [256]–[258].

Today, there are two ways in which owners can apply to the programme. The first is the renovation of the initiative of the housing association or community leader. In this model, renovation is carried out on the initiative of the residents through a housing manager. In the model "Renovation at the initiative of the municipality," the municipality selects the most inefficient energy-using apartment buildings and appoints the manager. In this model, the owner is not responsible for project [259].

After preparation, a loan was applied to the bank. For this to be accepted, it is necessary to consider bank requirements. One is that only approved apartment buildings with regulations valid until 1993 can be built [259]–[261].

Typical measures implemented for renewable energy projects are [259]:

- Renewal of heating and/or hot water systems;
- Installation of renewable energy production equipment;
- Repair or modification of the ventilation system, including installation of a mechanical ventilation system with heat recovery;
- Insulation of the roof, external walls and basement floor;
- Glazing of balconies;
- Replacement of windows and external doors;
- Refurbishment of lifts;
- Renewal of general electrical and lighting systems.

In terms of financial support, this programme fully covers all costs related to the administration of the project, the preparation of the technical document, and the supervision of the project. In addition, subsidies for hard projects depend on the family's income. For low-income families, the state covers the entire investment, while for others, until 2012, 50% of the investment was covered by the state, and this amount has now been reduced to 30% [256].

6.2.14 New Zealand

6.2.14.1 Warmer Kiwi Homes Programme

The Warmer Kiwi Homes Programme (Table B 14- Appendix B) is a government programme administered by the Energy Efficiency Conservation Authority (EECA), and its main objective is to make New Zealand's homes more efficient and healthier. This programme was implemented nationwide in 2021 with a focus on low income homeowners [262] with a total funding of $25 million (€13.6 million) [263].

When applying for this programme, the applicant's eligibility should be checked on the programme's website so that they understand what types of measures they can apply for. The scheme administrator will then put the applicant in touch with the appropriate installer to carry out the work. At the time of installation, the applicant will have to pay the difference of the missing value, this value can still be paid by some local communities that add an extra funding [262].

To be eligible for this programme, applicants must own and live in a dwelling built before 2008 and be in possession of a social security card, or live in a low-income area where the dwelling does not have ceiling and floor insulation or a functioning heating system. The eligible typologies for this programme are [262]:

- Insulation;
- Heat pumps;
- Wood burning stoves;
- Pellet stoves.

6.2.15 Northern Ireland

6.2.15.1 Affordable Warmth Scheme

The Affordable Warmth Scheme (Table B 15 - Appendix B) is a funding scheme that seeks to tackle the effects of FP and housing inefficiency in Northern Ireland [264].

Applicants eligible for the scheme must be residents in Northern Ireland, own and occupy the applicant's home, rent the house from a private landlord and have a gross annual income of less than £23 000 (€26 805) [264].

As part of the application process, a team will visit the applicant's home to check eligibility before any application is made and will continue to support families throughout the programme. This team will assess the house and make a package of recommendations, and only these will be funded by the programme [264]

The measures considered eligible for the programme are [264]:

- Insulation;
- Ventilation;

- Draught proofing;
- Heating systems;
- Windows;
- Solid wall measures;

The total cost of these measures will be limited to a maximum of £7 500 (€8 740) or £10 000 (€9 323) in the case of recommendations for home insulation. Should the value of the measures exceed these limits, the reason for this must be justified with the necessary documentation. If the Grant Office does not accept the justification, the applicant must pay the difference [264].

6.2.16 Poland

6.2.16.1 Czyste powietrze

The Clean Air Programme (Table B 16 - Appendix B) aimed to improve air quality and reduce GHG by replacing heating sources and improving EE in single-family homes. The programme had a target of renovating approximately 3 000 000 homes.

It was financed by grants from municipalities and banks totalling PLN 103.3 thousand million (€23.1 billion) and will be implemented on a national level with a special focus on EE and EP [265], [266].

The Clean Air Programme was divided into three parts. These three parts differed in terms of the form of funding for the beneficiaries and the beneficiaries themselves who are eligible for the option [265], [266].

In the first part of the programme, the beneficiaries were natural persons who owned or co-owned single-family dwellings or single-family dwellings in buildings and whose annual income did not exceed PLN 135 000 (€30 216). The forms of financing for these applicants were grants or subsidies for partial repayment of a bank loan (according to a specific list of selected banks) [265], [266].

In the second part of the programme, the average monthly income per beneficiary was not to exceed PLN 1 894 (€423) for a multi-family family and PLN 2 651 (€593) for a single-family family. The forms of co-financing for Part 2 were the two already mentioned for Part 1 of the programme, with the addition of subsidies with pre-financing and loans from municipalities as additional financing [265], [266].

Finally, in Part 3 of the programme, beneficiaries could not exceed the average monthly income per household member of PLN 1 090 (€243) for flats with more than one occupant and PLN 1 526 (€341) for apartments with only one occupant. Beneficiaries were eligible only if they received proven direct social assistance from the Polish state. In this programme area, co-financing was provided through grants (not bank loans), pre-financing grants and loans provided by municipalities [265], [266].

In the three parts of the programme, there were three typologies respectively, similar between the parts, differing only in the financing and installation of specific systems. In general, the eligible interventions for the three programme options were the replacement of an inefficient heat source with air-to-water heat pumps or another system, solar collectors for heating, photovoltaic systems, mechanical ventilation, insulation and installation of windows and doors [265], [266]. All these measures had different types of funding, considering the different parts of the programme. The following table (Table 10) details the maximum amounts per intervention option with other aspects to consider. It is important to note that in addition to this funding, energy audits and project management costs are also considered eligible [265], [266].

Table 6-7 - Financing guidelines for the Clean Air Programme.

Funding								
Part 1			Part 2			Part 3		
Op.1	Op.2	Op.3	Op.1	Op.2	Op.3	Op.1	Op.2	Op.3
Maximum values With thermal upgrade: PLN 66 000 (€14 772) Without thermal upgrade: PLN 41 000 (€9 176)	Maximum values With thermal upgrade: PLN 56 000 (€12 534) Without thermal upgrade: PLN 31 000 (€6 938)	Maximum values With thermal upgrade: PLN 33 000 (€7 386) Without thermal upgrade: PLN 13 000 (€2 909)	Maximum values With thermal upgrade: PLN 99 000 (€22 158) Without thermal upgrade: PLN 59 000 (€13 205)	Maximum values With thermal upgrade: PLN 81 000 (€18 130) Without thermal upgrade: PLN 41 000 (9 176€)	Maximum values With thermal upgrade: PLN 48 000 (€10 743) Without thermal upgrade: PLN 25 000 (€5 595)	Maximum values With thermal upgrade: PLN 135 000 (€30 216) Without thermal upgrade: PLN 79 000 (€17 682)	Maximum values With thermal upgrade: PLN 115 000 (€25 740) Without thermal upgrade: PLN 59 000 (€13 205)	Maximum values With thermal upgrade: PLN 70 000 (€15 667) Without thermal upgrade: PLN 40 000 (8 953)

6.2.16.2 Stop Smog

The Stop Smog Programme (Table B 16 - Appendix B) complements the Clean Air Programme but focuses on the most vulnerable households and municipalities with the greatest air quality problems. This programme was administered by the Ministry of Climate and Environment together with the National Fund for Environmental Protection and Water Management [267].

In this programme, municipalities applied for the programme and received up to 70% of the funding, and had to provide the remaining 30% of the required amount. With this

amount, applicants could receive up to 100% of the cost of their projects in the form of non-repayable grants [267], [268].

Several requirements had to be met for the municipalities' applications to be accepted. In particular, municipalities had to submit changes to at least 1% of their buildings or at least 20 buildings, and these measures had to reduce consumption by 30% [267], [268].

This programme has so far received a maximum of PLN 180 million (€40.2 million) from the Fund for Thermal Modernisation and Innovation [267], [268].

The main objective of this programme was to reduce emissions and improve air quality and EE in buildings by implementing low-emission projects. These projects include the replacement of air or water heating systems with low-emission systems, micro-installations of renewable energy sources, heat pumps, connection to district heating or gas networks, insulation of walls, roofs and ceilings, replacement of windows and doors, elimination of linear and point thermal bridges and repair of chimneys [269].

In addition, all works necessary to implement the measures, such as services, maintenance, insurance, construction projects and other documentation, are eligible [269].

The amount of funding depends on the population of the municipality. For municipalities with up to 100 000 inhabitants, the funding rate is 70%. For municipalities with more than 100 000 inhabitants, the funding rate was less than 70%. There are also thresholds for project funding. Specifically, the average cost of implementing a project for one building or for a building with two separate units cannot exceed PLN 53 000 (€11 862) [267], [268].

6.2.17 Portugal

6.2.17.1 Vale Eficiência

The "*Vale Eficiência*" (Table B 17- Appendix B) is part of the Portuguese Recovery and Resilience Plan (RRP) and is framed within the investment TC - C13 - i01 - Energy Efficiency in Residential Buildings of the component C13 - Energy Efficiency in Buildings. It aims to alleviate EP among the Portuguese population through the distribution of vouchers worth €1 300 plus applicable VAT. In addition to reducing the vulnerability of the population to this risk situation, this measure also encourages the renovation of buildings, improving their habitability and the health and well-being of families. Thus, the programme has as its sole focus the fight against EP and covers only the mainland of Portugal [270], [271].

The programme is managed by the *Fundo Ambiental* (FA), with the support of the Portuguese Energy Agency (ADENE) and the Directorate General of Energy and Geology (DGEG). The initial budget of the programme was €31 980 000, the bulk of

which is financed by the RRP and the remainder related to VAT by the Environmental Fund (FA). This is equivalent to 20 000 vouchers, though 100 000 vouchers are planned to be issued by 2025, with a total budget of €162 million [270]–[272].

These vouchers make it possible to pay for the interventions with the companies/suppliers participating in the programme. The interventions carried out should make it possible to improve the energy performance of the dwelling. To this end, the measures covered by the programme include the replacement of windows, the application of insulation to walls, roofs and floors, the replacement of entrance doors, the replacement of water heating systems and the installation of solar panels for electricity production [270], [271].

The beneficiaries of the programme are persons with an electricity contract who are beneficiaries of the social tariff for electricity (TSEE), who own and permanently reside in the dwelling for which they apply and who have not previously applied for the programme. In addition to the beneficiaries, the suppliers must also register with the programme to ensure that they meet the criteria established by the FA. Once the voucher has been issued to the beneficiary and the companies have registered, the families can look for the best budget to carry out the measures, with 100% financing up to a value of 1 300€ (+ VAT) paid by the FA [270], [271].

6.2.17.2 Edifícios + Sustentáveis

Edificios + Sustentáveis (Table B 17- Appendix B) was a programme created in 2020 with a total amount of 9.5 million euros for interventions aimed at the sustainability and energy renovation of housing. After COVID-19, the creation of a 2nd phase was fundamental for the recovery of the economy. Thus, in 2021, the second phase of the Edifícios + Sustentáveis programme was created, which is already included in the scope of the RRP. It is also part of the European "Renovation Wave" initiative, which focuses on the EE of buildings. As in the case of VE, it is also included in the investment TC - C13 - i01 - Energy Efficiency [273], [274].

The programme was managed by the FA initiative with the support of ADENE and DGEG. The funding of the programme was €30 000 000 from the RRP. The programme's objective was to promote renovation, decarbonisation, EE, water efficiency and circular economy, contributing to the improvement of energy performance and the reduction of primary energy consumption by 30% in the intervened buildings. Therefore, the programme covered the entire national territory, focusing on EE [273], [274].

The beneficiaries of Edificios + Sustentáveis were persons with the necessary property rights to carry out the measures covered by the programme, such as owners, co-owners, or undivided estates. Similar to the criteria for eligible beneficiaries, there were also criteria for eligible dwellings. Only dwellings (single-family, multi-family or

autonomous fractions) built and authorised by 31 December 2006 or 1 July 2021 (depending on the intervention typologies in question) were accepted [273], [274].

The eligible typologies were the replacement of windows; the application or replacement of thermal insulation in roofs, walls, or floors; environmental and water heating and/or cooling systems; installation of solar panels for energy production; and interventions aimed at water efficiency and bioclimatic architectural interventions [262], [263]. The financing of the measures was approximately 85% of the eligible costs (VAT was excluded from these figures), and each beneficiary was limited to a value of 7 500€ per single-family building or autonomous fraction and €15 000 in the case of multi-family buildings, considering only interventions paid since 7 September 2020. A financing of 85% was also granted, with a limit of €200 for individuals who wanted technical assistance during the process and the energy certification of the property [273], [274].

A new programme phase was recently launched (July 2023) - "Support Programme for More Sustainable Buildings 2023". This new notice presented some changes and updates compared to the previously analysed programme. The programme has a budget of €100 million, of which €30 million is earmarked for this first launch. Only permanent housing is eligible, and the incentive ceiling is just €7 500. The limits per typology were also changed, increasing the values for windows and insulation. In addition to these changes, increases have also been made for geographical location (10%) and the number of applications submitted (5 or 10%). Doors and bioclimatic architecture have been removed from this notice. Beneficiaries with eligible expenses of €5 000 or more in this notice must submit an energy certificate before and after the implementation of the type of intervention whose eligible expenditure has reached or exceeded.

6.2.18 Romania

6.2.18.1 Casa Eficient Energetic

The Casa Eficient Energetic programme (Table B 18 - Appendix B) was launched by the Romanian government in late 2020 with the aim of providing funding for works to increase the EE of single-family homes. The programme has a budget of 130 000 000 lei (€26.3 million), managed by the Romanian Environment Fund, and is considered a multi-year, nationwide programme [275]

Like many other European programmes, the Romanian programme provides technical assistance to applicants throughout the process. Specifically, after submitting the grant application with all the necessary technical documentation, it is possible to proceed with the execution of the project, and before and at the end of the project, an energy audit is carried out to ensure the veracity of the project [275]

The eligibility criteria for the application are that the applicant must be a natural person residing in Romania and the owner or co-owner of the house applied for. Under the programme, each application can receive up to 70 000 lei (€14 187) including VAT for each project, with a maximum of 60% of the total eligible costs [275]. The following interventions are eligible [275]:

- Thermal insulation;
- Heat pumps, condensing boilers;
- Solar thermal panels;
- Biogas production systems using organic household waste from single-family houses;
- Timers to control heating and cooling systems;
- Mechanical ventilation;
- Lighting;
- Air humidity;
- Windows.

The costs of the energy certification and the energy audit before the intervention and the implementation report after the intervention, carried out by a certified energy auditor of the building, are also financed by the programme, with a maximum of 2 500 lei (€506) including VAT for all these costs [275].

6.2.19 Scotland

6.2.19.1 Warmer Homes Scotland

In 2019, approximately 24.6% of all households were in EP (or FP). Since 2019, the Scottish Government has allocated £650 million (€757.5 million) to EP and EE programmes, and in 2015 launched home EE programmes, including Warmer Homes Scotland (Table B 19 - Appendix B), which are designed and delivered by local authorities and target households that are likely to be in a situation of EP, providing support for these families to improve their home through EEMs. The programme has been implemented on a national basis [276].

Beneficiaries of this programme must be owners or tenants of a private landlord, live in the dwelling for at least 12 months as their main residence, the dwelling must have a poor energy rating and must not have received assistance in the last five years of this funding scheme. In addition, beneficiaries must be over the age of 16 and in receipt of benefits, or over the age of 75 and have no functioning heating system [256].

As with many funding schemes across Europe, this Scottish scheme will involve an energy consultant assessing the applicant's home, checking its eligibility, and recommending the best measures to take. All recommended measures are, in principle

fully funded by the government, and the scheme must also approve the installer of the measures. Some specific measures may require a contribution from the applicant due to their high cost. In such cases, a loan administered by the Energy Saving Trust is also available [276].

The eligible typologies for this scheme are wall insulation, loft insulation, ventilation equipment, heating systems and renewable sources [276].

6.2.19.2 Home Energy Scotland Grant and Loan

The Home Scotland Grant and Loan Programme (Table B 19 - Appendix B) aims to help Scottish households improve the EE of their homes. The programme has been implemented nationally with a focus on EE [277].

To apply for the Home Energy Scotland Grant and Loan, it is necessary to contact the helpline, which will advise the applicant on the most appropriate measures to meet their energy needs. Following this contact, the application can be submitted. The applicant cannot carry out any work until funding has been agreed and then has 9 months to complete the work [277].

The scheme is open to all Scots who own and live in the applicant's home. In the case of self-build, only some measures are eligible, such as renewable energy systems.

Funding for EEMs will cover up to 75% of eligible costs, up to a maximum grant of £7 500 (€8 740) or £9 000 (€10 489) for eligible households. This grant is available to homes in rural and island areas and in locations without an accessible gas network. In addition to this funding, if you wish to install an energy storage system, you may be eligible for a grant of £2 500 (€2 913) if installed in conjunction with the package of measures.

The measures eligible for this scheme are glazing, loft and cavity wall insulation, renewable energy systems, energy storage systems and connection to the heat network [277].

6.2.20 Slovenia

6.2.20.1 ProgrammeZERO500

The Zero500 programme (Table B 20 - Appendix B) is a retrofitting programme focused on tackling EP by implementing measures to improve the EE of buildings. It is a national programme co-financed by the Ministry of Infrastructure and the EU through the Cohesion Fund and the total budget is €5.9 million [278], [279].

To be eligible for the programme, a person must own or co-own a dwelling in Slovenia, live there and apply for the project at that address. In addition to this first rule, the beneficiary of the programme must have received social assistance in the 12 months

prior to the application and must still be receiving it at the time of the application [278], [279].

There are also some rules for the applicant buildings. Only buildings or dwellings with planning permission granted before 2003 can be accepted [278], [279].

From the moment the application for the programme is filled in until the end of the intervention, the beneficiaries are accompanied by energy consultants. These consultants not only help applicants fill in the application form but also play a fundamental role in verifying the veracity of the project. Throughout the works, the consultants are responsible for carrying out mid-term visits to ensure that the funds are used for the intended purposes [278], [279].

The typologies covered by this programme are [278], [279]:

- Measure A - Insulation of the ceiling of an unused space;
- Measure B - Thermal insulation of external walls;
- Measure C - Installation of windows and doors;
- Measure D - Replacement of inefficient water heating systems with solar panels;
- Measure E - Replace an inefficient water heating system with a heat pump;
- Measure F - Installation of local ventilation with waste heat recovery.

The funding of the programme is 100% (non-refundable), up to a maximum of €9 620, VAT included. If one of the measures to be carried out in the house is Measure A and the project is approved, the amount of the grant is 100% reimbursable and this measure can be financed up to a maximum of €15 000. This figure changes the total maximum of € 9 620, no other measure can be implemented together. This can only happen if the cost of replacing the ceiling is less than this amount [278], [279].

6.2.21 Spain

6.2.21.1 Programa de ayudas para actuaciones de rehabilitación energética de edificios existentes (PAREER II) and Programa de ayudas para la rehabilitación energética de edificios existentes (PAREER-CRECE)

The first two programmes to be analysed are the "Programa de ayudas para actuaciones de rehabilitación energética de edificios existentes (PAREER II)" and the "Programa de ayudas para la rehabilitación energética de edificios existentes (PARRER-CRECE)" (Table B 21- Appendix B). The general objective of these programmes was to contribute to the achievement of the objectives set by Directive 2012/27/EU and the National Action Plan for Energy Efficiency 2014-2020, as well as to job creation and economic growth, mainly in the construction sector. The implementation period lasted from October 2013 to December 2018 and had a total budget of €404 million, allowing the renovation of 80 000 dwellings mainly promoted by communities of owners [280]–

[282]. The programme was implemented at national level, with a focus on EE and its funding comes from the Fondo Nacional de Eficiencia Energética. The aid provided by the programme works like loans or grants.

The existing typology groups in the programmes are typology 1–improving the EE of the thermal envelope; typology 2–improving the EE of thermal and lighting installations; typology 3–replacing conventional energy with solar thermal energy; and typology 4–replacing conventional energy with geothermal energy [281], [282].

Each typology has a base funding that can be increased according to certain criteria, such as the applicant belonging to a vulnerable group. Table 11 details these financing options. To increase the value of the financing, it was possible to combine the measures in such a way as to help the house achieve an "A" or "B" energy class or, alternatively, to increase the energy certification by two letters. Another interesting measure that could increase the base value is the location of a house. If it was in an urban regeneration area, it would be eligible for an additional subsidy. The combination of typologies in residential or non-residential buildings could also be a way to obtain additional support. This support can be provided to the applicant either as a cash payment or repayable loan [281], [282].

Table 11 - Funding by typologies in the PAREER II and PAREER-CRECE programmes. Source: [282]

Typologies	PAREER II		PAREER-CRECE	
	Basic funding	Maximum percentage of funding, considering additional aid	Basic funding	Maximum percentage of funding, considering additional aid
Typology 1 - Improving the energy efficiency of the thermal envelope	30%	60%	30%	60%
Typology 2 - Improving the energy efficiency of thermal and lighting installations	20%	70%	20%	70%
Typology 3 - Replacing conventional energy with solar thermal energy	30%	60%	25%	65%
Typology 4 - Replacing conventional energy with geothermal energy	30%	60%	30%	60%

Within each typology, all costs related to supporting the implementation of the measures of the typologies, such as project management and preparation, ancillary

works, and the preparation of the energy certification, were considered eligible costs of the programme. The non-eligible costs include permits, fees, and taxes [281], [282].

All eligible buildings were constructed and certified before 2007, and the beneficiaries eligible to apply for this programme met the following criteria [281], [282]:

- Owners of existing buildings intended for public or private use;
- Owners' associations or groups of owners of residential buildings for residential use (horizontal property);
- Owners were grouped as owners of buildings that have not been granted the constitutive title of horizontal property;
- Companies that operate, rent, or hold building concessions;
- Energy Service Companies (ESCOs) are understood as the broadest possible definition of organisations providing this type of service.

6.2.21.2 Programa Rehabilitación Energética de Edificios (PREE)

The Building Rehabilitation Programme (PREE) (Table B 21- Appendix B) was developed with an initial budget of €300 000 000 from the National Energy Efficiency Fund and the European Regional Development Fund (ERDF) [280], [283].

Under PREE, all autonomous regions and cities of Ceuta and Melilla received invitations from the government to submit applications, with each region having its budget. Following the invitation, the regions had approximately three months to submit their applications, which were processed on a first-come, first-served basis until the budget was exhausted [280], [283].

The typologies applicable in this programme were as follows: 1) improving the EE of the thermal envelope, 2) improving the EE of thermal installations, and 3) improving the EE of lighting installations [280], [283].

Each typology has basic funding that could be increased according to specific criteria. As in the previous programme, the combination of measures that increased efficiency to a higher level or the location of the dwelling was financially rewarded. The forms of payments were also similar [280]–[283].

In addition to these criteria, there is a breakdown of funding by dwelling type [280], [283]:

- Under Option A, existing complete buildings (single-family houses, multi-family houses, and buildings for any other use) could be financed.
- In Option B, considering the region's building typologies and climatic characteristics, regions could accept measures in one or more dwellings or facilities of the same building, considered individually.

For these measures to be eligible, requirements must be met. Apart from the measures having to achieve and justify a reduction in the final energy consumption of at least 10%

compared with the baseline situation and a continuous reduction in CO_2 emissions, the dwellings had to have been built before 2007 [280], [283].

The beneficiaries of the programme are [280], [283]:

- Natural or legal persons, private or public, who own existing buildings for any use;
- Associations between owners or groups of residential buildings;
- Owners were grouped together as owners of buildings that had not granted horizontal property rights;
- Companies that operate, lease, or hold building concessions;
- Energy Service Companies (ESCOs) or providers;
- Local authorities;
- Renewable energy communities and citizens ' energy communities.

6.2.22 The Netherlands

6.2.22.1 Duurzame Energie en Energiebesparing (ISDE)

ISDE (Table B 22- Appendix B) is being implemented throughout the Netherlands and aims to help the population implement EEMs. The programme is financed by European funds and has a total budget of €624 million. The Ministry of Economic Affairs and Climate and the Netherlands Enterprise Agency are responsible for administering the funding scheme [284], [285].

People who own the dwellings in which they live are eligible for this programme. For their applications to be eligible, they must follow certain steps before filling in the application form. First, they must choose the measures they want to carry out. If they have difficulty in understanding what they need most, the programme offers access to an energy specialist who will make recommendations. Once the measure has been chosen, it is the applicant's responsibility to understand whether all the requirements for the measure have been met, apart from the need for the equipment/insulation to be installed by a company. Only once the material has been installed can the beneficiary apply to the programme [284], [285] The eligible typologies are [284], [285]

- Insulation measures;
  - Cavity wall insulation;
  - Insulation of facades;
  - Insulation of the ground or floor;
  - Roof or loft insulation or loft floor insulation;
- Insulation of windows.

For all these measures, there is a minimum and maximum number of square metres to be installed and the amount of subsidy is calculated based on the number of square

metres. The values vary between 24 euro/m^2 and 75 euro/m^2 [284], [285]. The other measures are:

- Connection to the heating network:
  - The funding for this measure is €3 325.
- Installation of electric cooking:
  - The funding for this measure is €400.
- Heat pump:
  - For this measure, the applicant has a list of eligible heat pumps and the minimum grant is € 500.
- Solar thermal solutions:

All these measures have different eligibility conditions that the beneficiary must consider [284], [285].

6.2.23 Wales

6.2.23.1 Warm Homes Programme Nest

The Warm Homes Nest programme (Table B 23 - Appendix B) is a scheme that provides energy advice and funding for EEMs to low-income households and those living in deprived communities in Wales [286]. Being administered by the Department for Environment, Energy, and Rural Affairs, in 2018, it had a total budget of £15.9 million [287].

People who are eligible for this scheme must meet a few requirements[286]:

- Own or rent a home from a private landlord;
- The accommodation is uneconomical;
- Someone in the household has a health condition (respiratory, circulatory, or mental health), and their income is below the income thresholds for health eligibility.

The measures eligible for this programme include the purchase of boilers, central heating systems and insulation measures. The funding for each of these measures is 100%. To start the application process, it is necessary to contact the Energy Advisors who will present the package of improvements to be funded [286].

7 REVIEW OF THE SCHEMES STUDIED

7.1 Energy Efficiency Schemes

EE in the residential sector is one of the key points of the energy transition. Work in this area is seen as a beneficial strategy for the population, as it not only potentially reduces the final use of energy for heating and cooling and thus CO_2 emissions, but also reduces the final value of the consumer's energy bill and increases employment in related sectors. One way to ensure the application of energy-efficiency measures in residential buildings is through financial incentives [151].

In this subchapter, a statistical comparative analysis is conducted between the funding programmes identified through the interviews. A total of 23 countries and 33 renovation schemes were considered. Several issues are considered, such as the renewal measures of each programme, the type of funding, and the amount of funding.

Of the 33 programmes analysed, approximately 64% were aimed at increasing EE in the sector, without extra funding for the most vulnerable groups. In the geographical analysis of the programmes, it was possible to conclude that most programmes were implemented at the national level (90%). The exceptions were Australia and Belgium (*Primes énergie - Régime* 2015-2019 (BE); Solar Homes Program (AU)).

In terms of the type of instrument used, EE programmes mostly operate with the "grants" instrument (57%), followed by a combination of grants and loans (29%), tax incentives (10%) and finally, loans alone (5%). Of all the programmes analysed, only the Italian programmes provided tax incentives to their beneficiaries (Eco-bonus and Super bonus). For loans, only the French programme (i.e. Eco-prêt à taux Zéro) works based on loans. The combination of instruments is carried out more frequently in Poland, Greece, Ireland, and Australia. In these programmes, regardless of the type of instrument used, the programme can either pay VAT to taxpayers. Of the 21 programmes analysed, 52% included VAT on eligible expenditure, while the remaining 48% either did not include VAT in eligible spending or had other ways of avoiding payment, such as making the VAT on eligible measures null. The Boiler Upgrade Scheme and the Home Energy Scotland Grant and Loan are two programmes in this situation.

Regarding the funding origin of the programmes, there are three ways to analyse: where the funding comes from, the total amount of funding, and how much funding per EEM. Regarding funding sources in European countries, the current funding comes primarily from European funds, but there may always be a complement from the national state budget. Approximately 43% of the 21 analysed programmes focusing on EE have European funds as their exclusive source, the most used being the Recovery and Resilience Facility, followed by the European Regional Development Fund. Some 29% use only national funds to support these schemes, such as the Romanian programme

funded by the Romanian Environment Fund. Another 19% used a combination of European and national funding. The remaining 10% use other funding sources, such as banks, as in the case of the "*Eco-prêt à taux Zéro*", which operates in the form of loans. This amount generally varies between €105 thousand million and €30 million. Direct funding to the beneficiary is directly linked to the importance of the energy-efficiency measure. However, this funding generally has an average of 50%, with a maximum value per applicant, since, in most cases, the same can apply for more than one EEM. There are exceptions, such as the Italian programme that finances the measures at 110%, giving the candidate an extra incentive for renovating their home. Another exception is Bulgaria, which has a programme (Energy Efficiency of Multi-Family Residential Buildings National Programme) that finances all interventions at 100%.

Under the eligible EEMs to be supported, 14 energy/buildings/water related renovations were identified in 21 EE programmes as described below:

- Insulation (e.g. Roof insulation, Walls insulation);
- Windows;
- Solar protection;
- Doors;
- Heating or/and Cooling equipments (e.g. Heat pumps, Air conditioning, Space heating and/or cooling);
- Domestic Water Systems (e.g. Heat pump, Biomass boilers, Solar thermal solutions);
- Electricity production (e.g. PV panels);
- Ventilation;
- Lighting installation;
- Water efficiency solutions;
- Energy services (e.g. Audits, Certification, Projects, Building Energy Rating (BER))
- Monitoring systems (e.g. Building automation systems);
- Structure Measures (e.g. Anti-seismic measures, Removal of architectural barriers, Bioclimatic architecture solutions);
- Other measures (e.g. Elevators, Electric vehicles).

Overall, in these 21 programmes, the measures that have the highest representation are heating and/or cooling equipment (n=18), insulation (n=17), domestic water systems (n=15), and windows (n=12) (Figure 6). The measures with less weight were other measures (n=2) and water efficiency solutions (n=1). The "Energy Services" use is the one that is related to audits, site designs and issuance of EPCs, i.e. everything that can enable

interventions to be carried out within the programme requirements. This use only occurs in six of the programmes checked, for example in Poland, Ireland, Scotland and Belgium.

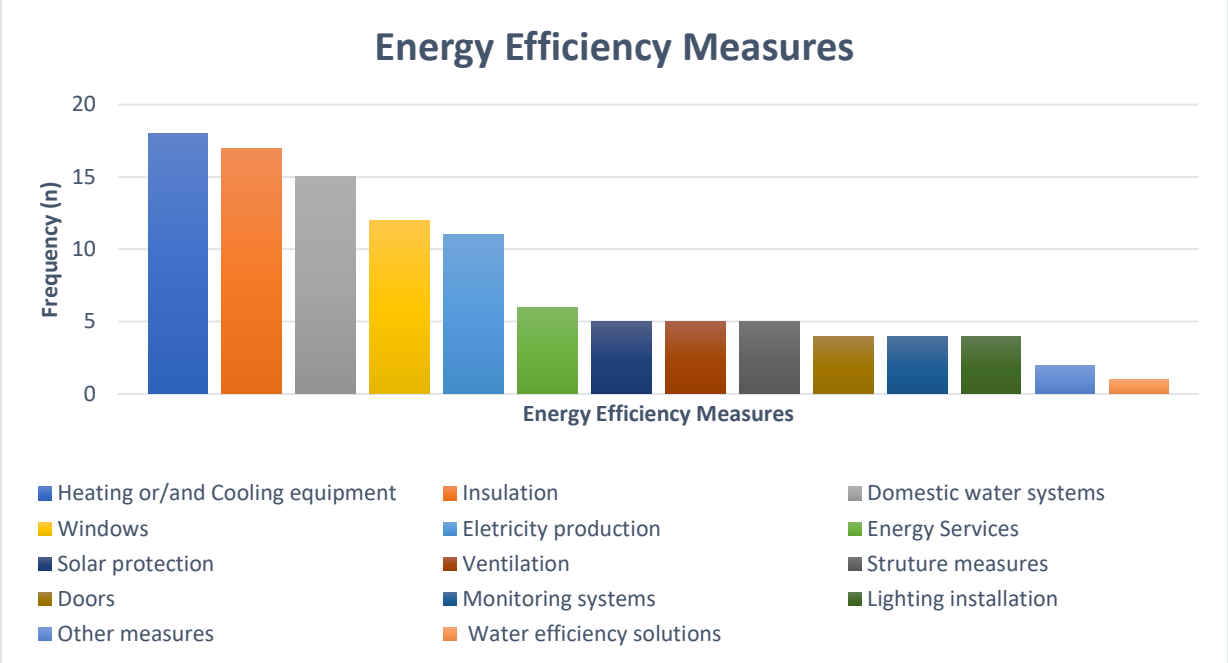


Figure 7-1 - Frequency of each EEMs in Energy Efficiency Schemes.

The architecture of the 21 programmes analysed in this chapter presents many differences, but the basis of application in most cases is the same; that is, the individual himself who applies for the programme. However, some programmes have different characteristics right from the start, such as Bulgaria and Spain. The Bulgarian programme (Energy Efficiency of Multi-Family Residential Buildings National Programme) works on a decentralised model. The municipalities are responsible for assessing the situation of different buildings and overseeing both the interventions and application process. The interventions carried out in each dwelling were also selected according to the home energy audit carried out.

Another important requirement is that all applicants to be eligible must own their own home, and not all programmes place requirements for the age of the building, only Portugal, Spain, Bulgaria, Ireland, Greece, the Netherlands, and Belgium.

In terms of paying for the interventions, there were four options in the programmes studied. In the case of loans, the applicant must apply to receive this funding before the interventions begin (the German case). Other programmes only pay for the interventions once they have been completed, and the applicant is responsible for the entire application process (Portuguese case - "Edificios + Sustentáveis"). In other programmes, before the applicant carries out the interventions, they must register with the programme so that they can be accompanied by an energy consultant. As a rule, in these cases, the

applications were only considered eligible if the interventions advised by the consultant were carried out (Slovenian case) and then the payment was made to the companies once the applications had been finalised. The Australian case differs in that payment is entirely the responsibility of the programme. In other words, applications are fully funded, and payments are made between the entity responsible for the programme and the companies.

7.2 Energy Poverty Schemes

In this subsection, a comparative analysis is conducted of the 12 funding schemes identified through the interviews, with a focus on EP. In addition to the programmes studied in the previous chapter, this one will explore programmes focused on EP. Of the thirty-three programmes analysed, ten only aimed to reach the most vulnerable populations (30%) and two (6%) had sub-sections: one only for the most vulnerable populations (in a situation of EP or beneficiaries of some social support) and the other for the whole population The two programmes with these characteristics are Lithuania's *Daugiabucių namų atnaujinimo (modernizavimo) programme* and Cyprus' Grand Schemes for Energy Efficiency and Renewable Energy Sources.

Of the 12 programmes studied, in 11, the individuals themselves made the application. One exception is the Polish "Stop Smog" programme. In this program, municipalities with the worst air quality were selected. When these applications are accepted, the municipality receives base funding from the national government, which allocates funding to applicants from these regions. For these applicants, who belong to more vulnerable groups, to receive full funding, the municipality must subsidise the remaining amount (government funding only applies to 70% of the eligible cost). Regarding geographical scale, about 92% of the programmes under study are implemented at the national level, except for the Polish Stop Smog programme, which is implemented at the regional level.

When we look at the type of instrument used in each program, as is the case for EE programmes, direct subsidies (48%) are the most used. Next, the combination of grants, loans, and stand-alone loans presents an example program. In the case of a combined approach, we have the Scottish Warmer Homes Scotland programme, and in the case of isolated loans, we have the Lithuanian *Daugiabucių namų atnaujinimo (modernizavimo) programme*. No tax incentives were found in this group of 12 programmes.

In the VAT analysis, the discrepancy between paying and not paying VAT was smaller than in the EE programmes. About 42% of the programmes pay VAT to beneficiaries, as is the example of the Portuguese programme VE. Programmes that do not pay VAT to

applicants represent approximately 33% of the total programmes analysed, such as Ma Prime Renov. The programmes of the UK countries are all finance materials, where VAT is 0%. In other words, VAT is not paid by either the programme or the beneficiary.

As with the EE programmes, we will also analyse the financing of the programmes in three aspects: source of funding, total funding, and funding for applicants. Regarding funding origin, the total number of programmes funded by European funds was the same as the number of the schemes financed by national funds. The schemes with national funding are mostly those outside the EU: the Warm Homes Programme Nest (Wales), Affordable Warmth Scheme (Northern Ireland), Warmer Homes Scotland, and Warmer Kiwi Homes Programme (NZ). The total budget of these programmes is mostly lower than those practised by EE programmes, with the highest value in the French programme *Ma Prime Renove* (FR) and the lowest in Programme ZERO500 (SI). However, this trend was not observed in all the cases. In the Portuguese and Polish cases, the budget allocated to EP programmes is higher than that assigned to EE programmes. Programmes focusing on both themes also had higher-than-average subsidies. Direct funding to the beneficiary was mainly 100%, subject to the maximum value (67%). The remaining 33% had funding value between 50-80%. In the case of the Warmer Kiwi Homes Programme (NZ), the programme only funds a maximum of 80% of eligible expenditures. Still, if the household has difficulty paying the remaining amount, the municipality is obliged to fund the amount.

Regarding the measures promoted by the programmes, the possibilities found were the same as in the EE programmes, with only differences in frequency (Figure 7). In this group of programmes, there is a greater focus on insulation measures (n=11), followed by heating and/or cooling equipment (n=10), windows, domestic water systems, and ventilation with the same weight (n=6). The least frequent typologies are structure measures, monitoring systems, and other measures (n=11). Energy Services were found in six programmes.

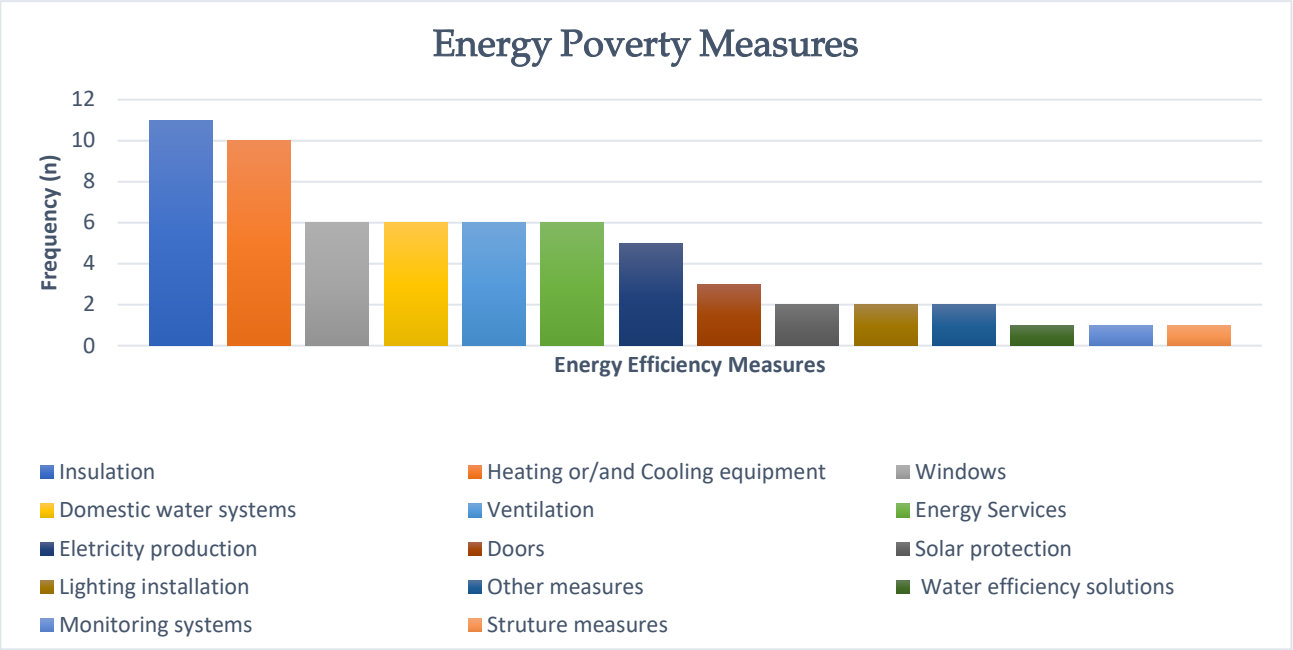


Figure 7-2 - Frequency of each EEMs in Energy Poverty schemes.

As far as programme architecture is concerned, of all the programmes under study, the only one that stands out is the Portuguese VE programme. This works in the form of a voucher, where the candidate only has to apply for it to be eligible for the programme. After the application is approved, the applicant must go to a company recognised by the programme and carry out the desired intervention (within the measures accepted by the program). In this way, payment to the company is made directly by the entity responsible for the program.

7.3 In-depth analysis of the financing schemes

In this study, thirty experts were interviewed to provide additional information on the positive and negative aspects of financial schemes applied in their countries. After studying all the responses and, consequently, all the programmes, 10 countries were chosen for a more in-depth analysis (Portugal, Spain, France, Italy, Ireland, Australia, New Zealand, Scotland, Lithuania, and Slovenia). Tables 11 and 12 summarise the programmes analysed in this chapter. These were selected based on the amount of information; studies found, language, and ease of document translation. This more detailed analysis considers all the points mentioned by the experts in all the steps involved in creating a financial scheme. The ten key points to be considered are the creation of a baseline, the objectives of the scheme, the identification of beneficiary groups, funding, the type of financial instruments, VAT, monitoring and evaluation, and EEMs.

Table 7-1 - Summary of the EE programmes studied in detail.

Country	Name	Years	Scheme Type	Funding	Typologies	Target Group	Homes Target	Costs/Benefits	Interviews
	Edifícios + Sustentáveis II	2020-2022	Grant	Up to 85%	Windows Insulation Doors Heating and Cooling equipment Domestic water systems Electricity production Water efficiency solutions Structure measures	General population	Buildings built before 2006	Interventions: 10 million m^2; Reduction of energy consumption: more than 486 000 MWh/year; Avoided emissions: over 38 000 tons eq/year of CO_2.	"Due to the definition and limitations of the typology, there is a lack of knowledge and a lack of the passive component of the building (insulation), i.e. there are few applications with the typology".
	PREE	2020-2021	Grant	Up to 35%	Insulation; Lighting installations; Heating or/and Cooling equipment	General population	Buildings built before 2007	Interventions: 80 000 dwellings	"Spanish programmes do not have specific programmes for the most vulnerable families"
	Eco-prêt à taux Zéro	2009 - 2023	Loan	Up to 30 000 euros	Windows Insulation Heating or/and Cooling equipment Domestic water systems	General population	not specified	Interventions: 82 297 actions	“the local partnership model should be developed to systematically implement a referral system, otherwise most families will not take the initiative - the bureaucratic system underlying financial support is very complex and long. Simplifying and shortening it could help.”

	Superbonus 110%	2020-2025	Tax incentive	Up to 110%	Insulation Heating or/and Cooling equipment Windows Electricity production	Owner and co-owners	Not specified	Not found	"Red tape is heavy, and the substantial increase in applications has led to speculation and price increases. This measure de facto excludes a large part of the housing, in particular those with temporary heating solutions"
	Better Energy Homes Scheme	2008 – 2023	Grant	Until €8 000	Insulation Domestic water systems Electricity production Heating or/and Cooling equipment Energy Services	Owner and co-owners living in the dwelling	Buildings built before 2011/2021	Interventions: 230.000 homes Avoided emissions: 294.4 $KtCO_2$	"The problem with national schemes is that they don't really address the fact that EP is far worse in rural areas, especially in the north west of Scotland where the weather is worse. "
	Solar Homes Program	2018 – 2023	Grant/Loan	Between $1 000 and $2 950	Electricity production Domestic water systems	General population	not specified	Not found	"Many renovation subsidies focus on technologies and don't address other basic retrofit considerations or address basic housing quality issues. (…) we do not have a strong retrofit industry in Australia and so there is some limitation to who can do the various work.

Table 7-2 - Summary of the EP programmes studied in detail.

Country	Name	Years	Scheme Type	Funding	Typologies	Target Group	Homes Target	Costs/Benefits	Interviews
	Vale Eficiência	2021-2023	Grant	€1300 + VAT	Windows Insulation Doors Heating and Cooling equipment Domestic water systems Electricity production	Economically vulnerable families in a situation of potential energy poverty, are eligible for the social electricity tariff (TSEE);	Not specified	Interventions: 6 302 buildings; Reduction of energy consumption: 48.631,82 MWhep/ year; Avoided emissions: 3.812,00 ton eq/year	"Lack of knowledge and a lack of the passive component of the building (insulation)"
	Warmer Kiwi Program	2021-2022	Grant	Up to 80%	Insulation Heating or/and Cooling equipment	Low-income home owners.	Buildings built before 2008	Interventions: 75 242 buildings; Reduction of energy consumption: not specified MWh/year; Avoided emissions: not specified [288]	"Fund broader building repair and improvement work to support home retrofit programmes";
	Warmer Homes Scotland	2013 – 2023	Grant/Loan	Total funding	Insulation Heating or/and Cooling equipment Electricity production	Vulnerable private sector households (tenants or	Not specified	Not specified	Not specified

					Domestic water systems	owner-occupiers)			
	Daugiabucių namų atnaujinimo (modernizavimo) programa	2004-2023	Grant	Total funding	Heating or/and Cooling equipment Domestic water systems Ventilation Insulation Windows Other measures	General population and low income families	Buildings built before 1993	Interventions: 224 buildings; Reduction of energy consumption: 58386.16 MWh/year; Avoided emissions: 13603.91 tons/year of CO_2 [289]	"The improvement could be done for the individual houses as well (…). "
	ProgrammeZERO500	2022-2023	Grant	Total funding	Insulation Windows Doors Ventilation Domestic water systems Heating or/and Cooling equipment	Vulnerable citizens living in buildings suitable for energy refurbishment.	Dwellings dating from before 2003	Not specified	"The scheme is not available for tenants and there is no other scheme that would be available for tenants, affected by energy poverty, which is not so good."

7.3.1 Design guidelines and purpose of schemes

Properly formulating energy policies and clearly defining the objectives to achieve are crucial to financing schemes' success. The main challenge is trying to achieve a sustainable market transformation [290].

In the interviews, at least two experts mentioned the lack of a clear definition of objectives in formulating schemes as one of the main problems. According to expert 4, these shortcomings can have consequences throughout the scheme's operation, such as '*... coordination difficulties between national/regional and local administrations and lack of basic budgetary commitments*'. A study by Bouzarovski *et al.* [36] confirms this situation, stating that most European countries do not present a detailed discussion of their EE policies and objectives related to reducing energy consumption and the situation of EP [291]. An example is the Spanish programmes such as PREE. This programme provides additional funding for EEMs for households, but the programme regulations do not mention any EP-related objectives. As no programme in this country targets only the most vulnerable, this lack of targets can lead to misinformation and a lack of incentive for households to make these energy investments.

There is currently a lot of development in the building sector, but they are not the only ones trying to promote these measures. NGOs, environmental activists and EP experts see this issue as fundamental and have different objectives. This allows for other objectives and solutions to societal and household problems [61]. Therefore, programmes that promote EE and reduce EP should be encouraged if their objective is clear. An example is the Daugiabucių namų atnaujinimo (modernizavimo) programme (LT). Here, part of the funding goes exclusively to the most vulnerable households, who receive 100% of the interventions' cost.

According to the literature, these programmes generally seem more successful. Still, other objectives must also be well articulated for this to happen, such as air quality, household health, increased productivity, and energy security [292]. Before developing these programmes, it is also necessary for those responsible to have a thorough knowledge of the characteristics of the scale at which the programme will be applied, i.e. knowledge of the climate and the characteristics of the population and buildings [293]. The involvement of local authorities is essential in this respect.

In several of the programmes analysed, regional and local governments coordinate and monitor the programmes. This appears to be beneficial regarding results, particularly in reducing EP [6], [282]. Examples are the Spanish PREE programme, where the different regions coordinate the programme and have their own budget and the Daugiabucių namų atnaujinimo (modernizavimo) programme. This programme has two application models, one of which the municipality is responsible for identifying the least efficient buildings. This identification in the latter case is only possible with the involvement of

local governments, as they are closest to the families and can understand their needs [294]. According to Economidou *et al.* [153], this closer level of governance allows for better prioritisation of interventions, targeting the most inefficient buildings and/or those occupied by vulnerable people. However, these examples are by no means the majority. In approximately 70 per cent of the schemes studied, the entire study population was eligible. This is similar to the study by McAndrew *et al.* [292]. This article analysed more than 153 studies from different regions, such as Europe, the USA, the UK, Australia, and New Zealand. It was found that 78% of the programmes were aimed at the general population and were motivated by the need to reach as many people as possible. However, this can lead to ambiguous conclusions and a lack of relevance to the programme.

The longevity and level of ambition of a programme are also issues to be considered when developing a programme. Among the programmes analysed, the average number of years of implementation is six. This shows that there are still few programmes that are implemented with a long-term strategy, which is necessary to stabilise the market, create awareness and avoid price speculation and shortages of equipment and materials for the installation of EEMs, as happened in the case of the Superbonus 100% programme which was only stipulated for five years [295].

7.3.2 Identification of vulnerable consumers

For programmes that focus on reducing EP to be successful, this group of people must be correctly identified. The lack of a proper methodology for this identification was one of the most frequently mentioned shortcomings during the interviews. The Bulgarian expert states: "*We need an integrated approach to EP and building renovation. First, we need to identify the causes of EP, which can be low income, non-insulated dwellings, or even wrong user behaviour*". The Cypriot expert states that "*the main recommendation is that the definition of vulnerable consumers should be reviewed to target vulnerable consumers better and increase the effectiveness of measures*". In Scotland, the expert states that "*the problem with national schemes is that they do not address the fact that FP is much worse in rural areas, particularly in the North West of Scotland where the climate is worse. This is largely due to the lack of mains gas, which means people have to use electric heating, which is very expensive*".

Some of the countries surveyed have policies in place to identify the most vulnerable families so that they can receive government support to pay for their energy costs. It was found herein that Portugal, Spain, Poland, Italy, France, Slovenia, Ireland, Bulgaria, Lithuania, Greece, Cyprus, New Zealand, and the UK have well-documented policies. These policies are important for identifying the particularities of energy injustice for different groups, strengthening a policy response, reducing some of the stigmatisation around energy poverty, and avoiding assumptions about the needs of vulnerable

households [296]. At the same time, they do not reach the entire vulnerable population, so the criteria need to be reconsidered [297].

Another drawback of several schemes described by the Slovenian expert (Expert 16), is that the programmes do not cover tenants. According to Bird & Hernández [298], the main difficulty in reaching these people is partly due to the phenomenon of split incentives, where landlords have no incentive to improve their rented properties with EEMs and solar PV because they are responsible for the costs but do not see the benefits [298]. Another reason tenants are not reached is the rent increase that landlords potentially charge after home improvements, which can even lead to evictions (i.e. what is called renovictions). To prevent these phenomena, national governments should prevent tenants from being evicted or having their rents increased for a certain period after the interventions. Another measure that could also be relevant is the implementation of minimum EE standards, which would effectively make EE improvements in dwellings compulsory [294].

7.3.3 Type of financial instruments and funding of schemes

As seen in Chapter 7.1, the vast majority of the programmes studied in this dissertation used subsidies, followed by combinations of subsidies and loans, then loans alone and tax incentives. This trend was also observed in other studies in the scientific literature [151], [299]. Subsidies are generally the most widely used form because they are very attractive to the population and maximise EE gains, but they also have several limitations. One of the main limitations is the transaction costs of implementing these instruments (e.g. administrative and evaluation process); the second limitation is the possibility of misuse of the funds provided and the rebound effect they can have since consumers can often buy equipment just because they have the support of the subsidy and end up increasing their energy consumption, which goes against the objective of these schemes [148].

To address this problem, the number of programmes using a combination of financial instruments has increased recently. Warmer Homes Scotland is an example of this combination among the programmes reviewed. In addition to fully funding the measures for the most vulnerable groups, loans are also provided in extreme cases where the family cannot pay the initial purchase price [299]. However, besides subsidies alone, this combination may also have limitations. According to Rosenow *et al.* [57], this combination can sometimes lead to lower savings than if the instruments were used separately, as individuals may receive additional financing for the same amount of savings.

Another combination that can benefit the successful implementation of EEMs is the combination of financial instruments and information measures. Information policies have an educational aspect and help decision-making using psychological and

behavioural mechanisms [3], [300]. Warmer Homes Scotland is an example of a programme that uses energy audits to recommend measures that individuals should apply to their homes. Under the programme's rules, only these measures are funded by the programme, which means that individuals must carry out the recommended measures to receive the incentive. The Danish programmes implemented under the Innovate/One-Stop-Shop H2020 project or the Infinite Solutions IEE project show how effective these combinations can be. These programmes have managed to leverage very high levels of EE investment using information and education tool [280]. The use of white certificates EPCs is another instrument that helps to leverage investments, as there are often national or even local strategies that demonstrate the use of these instruments [280]. The analysis shows that no single instrument is perfect, not even a combination of financial instruments. A more holistic approach involving different policy categories is needed to make the system more effective and achieve the objectives set [299]. This requires an increase in funding.

Analysis of the programmes shows that the amount of funding and its sources vary considerably. The Italian programmes have the highest level of funding at over 100 thousand million euros between 2007 and 2025. This funding is a combination of European and national funds. There is currently some concern about the dependence of many countries on external funding to implement their programmes. This dependence is making European and international flows increasingly important [299]. One solution to reduce this dependence is to mobilise private investment with appropriate financial mechanisms[15], [302], [303].

7.3.4 Monitoring and evaluation

One of this analysis's main challenges was determining the cost-effectiveness of the different programmes. Only Portugal, Spain, Italy, Ireland, Lithuania, Slovenia, and New Zealand have published, or at least made easily accessible, the results of programme implementation [299]. In addition to the difficulty of accessing this information, the analysis methodology differs between countries, and it is not possible to directly compare programmes based on their results. According to its report, the Portuguese "*Edificios + Sustentáveis*" has funded over 70 000 applications and carried out interventions on more than 10 million m^2. Through these interventions, it has managed to reduce energy consumption by 486 000 MWh/year and avoid the emission of more than 38 000 tonnes eq/year of CO_2. The other Portuguese programme, Vale Eficiência (i.e. efficiency voucher), limited to the most vulnerable families, has paid for more than 6 000 applications. These applications cover 0.7 km^2, have avoided around 3 900 tonnes eq/year of CO_2, and reduced 48 600 MWh/year. The Lithuanian programme also described these figures. The programme intervened in more than 220 buildings, reducing consumption by 58386.16 MWh/year and avoiding more than 13603.91 t

CO_2/year. In the case of the Spanish PREE programme and the New Zealand Warmer Kiwi Homes programme, only the number of dwellings intervened was found, 80 000 and 75 242, respectively. The Irish and Italian programmes only provide figures for the number of interventions and CO_2 emissions avoided.

As we can see, many countries are using this type of instrument, but their effectiveness is still unclear [299]. Very few set ex-ante objectives and targets, and even fewer evaluate the results of programme implementation. Few programmes have also used continuous monitoring evaluations. According to the UK expert, "*one issue that has caused many problems for UK programmes is the quality of the refurbishment work, which, in extreme cases, can lead to a deterioration in the quality of the building*". This testimony illustrates the urgency of carrying out these checks. Some challenges commonly encountered in evaluating these programmes, which prevent them from being carried out, are data protection, the lack of common definitions and long, complex chains of funding interventions [304].

7.3.5 Energy efficiency measures

The experts' points of view were analysed for the EEMs supported in each programme. The Portuguese expert says, "*there is a lack of definition and reduced co-funding for the insulation typology in both Edificios + Sustentáveis II and VE*". According to him, this has led to a lack of application of the measure by candidates. Another problem identified by the experts was the "*limitation of the type of housing in the programmes*". The Lithuanian expert said the "*support schemes should be extended to all kinds of buildings and not just limited to single and multi-family houses*". The final problem identified was the choice of measures for the different programmes. The Australian expert expressed his displeasure that most Australian programmes focus on technologies and do not address basic rehabilitation measures or measures that promote quality. According to the expert, "*the rehabilitation industry is not sufficiently developed*".

It is clear from the interviews that the choice of EEMs and how they are managed is often not done correctly. For this to happen, it is necessary to be aware of the advantages and disadvantages of each measure when implemented in a particular dwelling. It is also important to note that applying them requires a good knowledge of the house, as not all measures work similarly when installed.

Most of the programmes analysed in this dissertation, in line with other studies in the literature, support the combination of EEMs, allowing for a more holistic approach. In contrast, only a few programmes support the deep renovation of dwellings [109], [299]. This renovation approach is essential to address the whole building and its structural performance, leading to more consistent and long-lasting EE improvements. In the case of multi-apartment buildings, this in-depth approach helps involve all residents without

excluding anyone based on their financial capacity [109]. In addition, these in-depth renovations can be seen by many owners as an invasion of privacy, often resulting in residents having to leave their homes for a period. To ensure that this does not become a barrier, it is necessary to provide reassurance and demonstrate the long-term effectiveness of these measures [109].

Different measures may have different outcomes and savings, as mentioned above. However, there are some that are generally the right choice for home renovation. Heating and cooling systems are the most frequently funded measures in all the programmes examined. The installation of heat pumps in dwellings reduces energy consumption and meets other objectives of several programmes, such as electrification of final consumption and increasing the share of renewable energy [305]. The second most common type of measure is individual insulation. These can reduce bills by between 4 and 9% if properly applied. The most efficient insulation is attic insulation, which, curiously, is also the rarest of the programmes studied. These measures can reduce energy losses by up to 20% [305].

The other most common measure is the replacement of windows and front doors. The performance of this measure is still unclear because, if done incorrectly, it can worsen the humidity in the home. However, if done correctly, it can reduce losses by up to 15% [306].

In addition to the eligible technical measures, the support schemes may or may not cover other costs. VAT is an element that is not consensual in the architecture of the programmes studied. The aim of removing VAT from this equipment is to encourage users to purchase it, and, as it is directly perceived by the consumer, it can lead to a significant increase in the number of applicants. However, if there is a price increase by retailers, there is a risk that the VAT reduction will not be noticeable and beneficial to consumers [153], [290].

8 Proposed architecture for a Future renovation scheme

Based on the results obtained in this study and all the grey and scientific literature previously reviewed, it has become clear that the programmes implemented in the countries under study have general flaws in their structure and development. The experts' recommendations and the problems and benefits identified in the programmes make it possible to develop a successful model for a programme to finance building renovation and combat EP. To do this, it is necessary to consider the characteristics of each country and the specific objectives each programme must achieve. In this chapter, the model will be developed for Portugal, but all the topics covered can be adapted to any country. Table 13 presents a summary model of the programme.

First, it is necessary to consider the objectives that the programme must take into account. Regarding the evaluation report carried out by ADENE (2023) [307], the "Edificios + Sustentáveis" programme managed to achieve all its objectives. This is an opportunity for the Portuguese government to be more ambitious in future programmes and to set more ambitious targets. As mentioned in Chapter 8.3.1, the combination of EE targets and EP reduction is a success story in the literature. Therefore, creating a scheme that covers these two priorities is recommended to avoid too many programmes and regulations.

Starting with the programme's framework, it would be divided into two large sections: one for the general population and one for the most vulnerable groups. These two sections would generally have the same rules, with a few exceptions mentioned in this chapter. An example of such a programme is the Cypriot programme "Grand Schemes for Energy Efficiency and Renewable Energy Sources". The companies responsible for carrying out the interventions would be on a list of companies accredited by the government and selected according to sustainability criteria, such as being certified by ISO 14001:2015 and the Eco-Management and Audit Scheme (EMAS).

Portugal does not have a clear definition of the stipulated objectives and a methodology for assessing the potential impact of its funding schemes (or at least one that is not publicised). To overcome this problem, it is necessary to select a set of indicators when defining objectives and targets that will help analyse the effectiveness of the programme throughout its operation and at the end. Standardising an evaluation process and involving all stakeholders throughout the evaluation is important for optimising knowledge. It is therefore necessary to define the ex-ante and ex-post aspects of each programme. First, the evaluator must consider the context of the analysis to determine the objectives of the instruments (ex-ante). In the ex-post phase, the aim is to analyse the existing policy mix and evaluate the selected instruments and their interactions using criteria to analyse individual instruments and design policy mixes

[287]. These criteria should be chosen according to the context and objectives of the programme. A widely used methodology is based on five evaluation criteria, which, once analysed, reflect the degree of success of the policy. The requirements for this evaluation are the need for the project (relevance), the use of resources and reasonable time (efficiency), the expectations met (effectiveness), the positive or negative effects that have occurred as a result of the project (impacts), the positive effects that continue after the end of the project (sustainability) [291].

In addition, various advisory/monitoring actions should be conducted during the course of the programme. These counselling/monitoring actions should be carried out in three phases and managed by the local authorities in cooperation with the energy companies due to their proximity to the population and ease of communication:

- Start of the application (optional): This measure should be available to applicants free of charge, especially for those with less knowledge about the best measures to apply to their homes. The aim was to recommend the type of intervention (list of priorities) to be carried out at home. This measure often leads to high levels of bureaucracy, long waiting times, and fewer people affected. However, they are good informative measures because they help the less aware population achieve higher levels of energy efficiency. One way to encourage the use of energy audit measures is to use thermal images of heat loss. According to the literature, this motivates households to reduce energy consumption and adopt energy-saving measures. In other words, it could be a mandatory mechanism for audits to use [308].
- In the middle of the intervention (only in case of complaints): This stage should be conducted only if the applicants lodged a complaint. The aim is to check whether the work is being carried out with quality and to increase the efficiency and productivity of companies. Accountability and quality are essential pillars of the long-term success of EE and EP support schemes.
- At the end of the intervention (mandatory): At this stage, an energy audit should be conducted with the aim of producing an EPC. These certificates should be carried out to understand the results obtained in each home from the interventions carried out and subsequently to help assess the effectiveness and efficiency of the scheme.

The programme's implementation period should be longer than five years to create stability and not affect the market. This would avoid an exponential increase in requests, which could lead to speculation and higher prices, as the Italian expert pointed out. These longer programmes also increase public confidence, as often, in shorter programmes, fewer people invest because of a lack of time to go through all the application steps.

For the programme to succeed, the choice of instruments must adopt a more holistic approach, combining financial, information instruments and OSS. Regarding information instruments, it is recommended that, in addition to the above-mentioned energy audits and certificates, the possibility of installing smart meters for consumers to monitor their consumption should be added. Regarding financial instruments, a combination of subsidies and low-interest loans is recommended. Subsidies should be made available to the general population, while loans should only be available to families with less capacity to make the initial investment. This is important for families that are not considered the most vulnerable. Low-interest loans should be administered by large Portuguese banks that can raise capital to offer refinancing options for small-scale loans for energy efficiency and renewable energy projects [15]. For these, the current methodology of the VE programme (vouchers) should be maintained, with the only recommendation being to invest in the relationship between the government and energy companies (such as EDP).

Another step that should be well defined in the programme's structure is the type of eligible applicants. For the general part of the scheme, eligible applicants should be homeowners, co-owners, and inheritors. In addition, it is recommended to pay special attention to tenants so that they can also apply for the programme, something that is not common in all programmes (Expert 16: "*The scheme is not available for tenants and there is no other scheme that would be available for tenants affected by EP, which is not so good*".) In the phase exclusively for people in FP, they should be identified through the social tariff, but this should be reconsidered in terms of identification. One recommendation is to use the Energy Poverty Vulnerability Index, a new EP index developed to map and characterise EP at high spatial resolution. This index helps to prioritise the most vulnerable regions [309].

The weight of funding allocated to each EEM should also be considered. Specifically, as insulation, windows, and heat pumps seem to have the most impact, they should receive the most funding. For the most vulnerable groups, all EEM typologies should be fully funded. VAT should also be funded only for the most vulnerable groups. All funding should be provided up to a certain threshold calculated according to the measure in question.

Other points should be considered for the success of the scheme. Communication campaigns should be carried out with local authorities, NGOs and on national and social media to publicise the scheme's benefits to the population. Information sessions at town halls and local councils are also very important. These campaigns have shown positive results regarding programme uptake, as evidenced by the Kirklees WarmZone (KWZ) programme in New Zealand [310]. To find out in detail what the applicant thinks about all stages of the process, a voluntary questionnaire should also be provided at the end of each application, in which the applicant can list the strengths and weaknesses of the

programme, allowing for in-depth knowledge from applicants and ideas for future improvement.

Dealing with all these points can potentially lead to excessive bureaucracy, which can be one of the main reasons why candidates drop out. To avoid this situation, the programme should be managed by national energy authorities, such as ADENE and DGEG (responsible for evaluating and managing the programmes), with the support of other stakeholders and local agencies (responsible for getting information out to the population, especially the most isolated) and the scientific community (responsible for setting the objectives and targets and the evaluation and monitoring methodology), together with the Portuguese government, to achieve the best possible results.

Table 8-1 - Topics to consider when developing an EE/EP funding scheme - Example for Portugal.

Topics to consider in the scheme architecture	Example
Targets and objectives	More ambitious targets Incentivising EE and reducing EP Definition of assessment indicators
Time implementation	> 5 years
Identification of vulnerable groups	Energy Poverty Vulnerability Index with Social Energy Tariffs
Instrument types	Grants and Loans EPCs and energy audits
Stakeholders	Banks, ADENE, DGEG, Energy companies, NGOs, IPSS, local governments and scientific community
Monitoring and assessment	Consultancy before implementation and post-intervention monitoring. During specific cases of failure
VAT	Paid to the most vulnerable groups
Beneficiaries	Owners, co-owners, inheritances, tenants, and EP groups
EEMs	Insulation, Renewable energy production, Windows and entrance doors, Heating/cooling equipment, Water heating, Bioclimatic architecture solutions;
External Communication	Marketing Campaigns Social media dissemination; Clarification sessions throughout the country
Others	Voluntary questionnaire

9 CONCLUSION

To achieve EE and EP objectives, the EU, UK, New Zealand, and Australia have launched several energy policies since the oil crisis in the 70s. Over the last few years, several important policies have been launched in the EU to incentivise EE and reduce EP. The EPBD, the "Clean Energy for All Europeans" package, the Energy Poverty Recommendation, the Renovation Wave and the "Fit for 55" package are some of the most important measures. In New Zealand and Australia, the main policies launched over the years relate to building certification through programmes such as NABERSNZ in New Zealand and NABERS in Australia. These programmes aim to help homeowners and tenants reduce their energy consumption and, therefore, the cost of their bills and emissions. Finally, the UK has been researching FP for several years and is at the forefront of policy development.

There are UK-wide policies to address these issues, as well as more localised policies for each country. Regarding EE, the main policies currently in place are energy company obligations, green disposal, EE of rented properties, social housing decarbonisation funds and housing modernisation programmes. Regarding direct support to the most vulnerable households, the current programmes are Winter Fuel Payments, Cold Weather Payments, and Warm Homes Discount.

A diversity of countries worldwide are increasingly establishing EE/EP schemes. To make funding schemes more efficient towards the goals of carbon neutrality in the sector, this study aims to analyse the functioning and effectiveness of programmes worldwide and explore possibilities for improvement. It also seeks to provide tools to help national governments identify the most vulnerable consumers, improve their housing conditions, reduce their energy bills, and improve their quality through measures and solutions that are more relevant to the problem and attractive to the population.

The EU MSs and the other countries studied have significant challenges ahead to promote deep energy renovations, reduce EP and increase the EE of their building stock. Over the years, many programmes have been giving households the opportunity to incorporate EE measures in their homes. However, renovations are uncommon and do not reach the desired levels. This highlights the need to increase the number of renovations and make them more complete regarding the interventions carried out (Bertoldi *et al.* [58]). On the other hand, this may increase the transaction costs of financing schemes and the interest/difficulty of households to implement them.

When it comes to reducing EP, identifying vulnerable groups is another essential factor to consider when discussing funding. These groups often don't have access to essential services such as affordable electricity. By helping these families, programmes can ensure that they have access to cheaper and more efficient energy without increasing

consumption. However, if this identification is not done correctly, EP policies can become ineffective, misallocating financial resources and leaving out those most in need.

The motivation for carrying out this study was to understand what programmes and policies other countries are applying and how Portugal can learn from them. The methodology used was based on expert interviews and scientific and grey literature. Thirty-three support programmes and eight consumer protection policies were analysed.

In terms of consumer protection policies concerning EP, it was found that many European countries and even Australia do not seem to have specific policies for groups in EP. They are included in the general poverty group and only receive social support. Regarding the subsidies studied, social support is usually used to identify individuals and households for programmes that tackle EP. This support takes the form of a refund or discount on the electricity bill. How this support is provided also varies from country to country, but in most cases, the population must register.

Other conclusions can be drawn from the renovation programmes. Firstly, many of the programmes identified are only concerned with promoting EE without additional conditions for the most vulnerable families. In the programmes that focused exclusively on combating EP, most measures were 100% financed, with no initial payment required from the applicants. The most used financial instruments in the programmes studied were grants, followed by a combination of grants and loans, and the funding of these programmes mainly was from European funds, except in the case of New Zealand and Australia. In terms of EEMs, most programmes focused on insulation and the installation of heating and cooling equipment. The exception was the Australian programme, which proved to be one of the only programmes, apart from the Austrian programme, to focus on only one EEM (energy generation through solar panels). The analysis showed that New Zealand and Australia were slightly behind the European countries in these policy areas. In addition to the conclusions drawn from the study of the programmes themselves, further findings were drawn from the areas for improvement identified by the experts. The main complaints were inadequate funding, non-involvement of tenants, bureaucracy, lack of information, lack of transparency, inflation and poor identification of vulnerable groups. In addition, the lack of evaluation and monitoring of the programmes was a key shortcoming identified in the analysis of around 90%.

With all these barriers identified, it was clear that there is still much work to be done in this area. It was concluded that the level of ambition of countries is still far below what is needed to make buildings carbon-neutral by 2050. At the European level, funds must be used more efficiently and effectively to help the most vulnerable and encourage the general population to change. A collaborative approach between different actors such as national, regional, and local governments, the private sector, NGOs, financial institutions, and the scientific community is essential. Establishing evaluation indicators

and a monitoring methodology is also important to verify the success of programmes and ensure their transparency. Finally, integrating EE incentive programmes with EP reduction strategies can be essential to reduce carbon emissions, increase access to energy and contribute to a more sustainable and equitable future for all.

In Portugal, the main problems identified were bureaucracy and lack of funding for the measures that generate the most savings, such as insulation. Considering these and other points identified throughout the study, it has been possible to develop a model programme that considers Portuguese characteristics but can be adapted to all countries.

In summary, the implementation of these financing schemes is increasing worldwide, but their analysis remains scarce and inefficient. As they are essential in the fight against EP, it is vital that the scientific community continues to work with government institutions to make the programmes successful. With these programmes, improving people's quality of life and moving the world into a more resilient and equitable era is possible.

This dissertation has had some limitations throughout its development:

- The availability of key information on policies and programmes from government agencies. It was often challenging to find the guidelines for the programmes studied.
- The lack of analyses of programme effectiveness. Most of the bodies responsible for managing the programmes did not provide evaluations of the programmes in question or provided outdated reports. What's more, where reports did exist, few indicated whether targets had been set. It was also impossible to compare programmes because each country has its own methodology.
- The different languages were a frequent limitation in analysing programmes and measures. In many cases, websites had to be translated automatically, which does not guarantee a 100 per cent correct understanding of the information. Another problem was that PDF documents could not be translated, meaning some countries were excluded from the analysis.
- The issue of language and access to information may also have resulted in some important schemes not being identified. The interviews were conducted to overcome this problem.

Several areas have further potential to be addressed in more detail in future work:

- In-depth analysis of how general financing should be designed to achieve the greatest possible energy savings in housing energy efficiency programs.
- Survey the population that has applied for this type of programme. Trying to identify the main barriers perceived by the population and what measures could be implemented to overcome them.

- Define the best EEMs to apply, considering the climate and the population's needs. In other words, more in-depth studies should be carried out on the state of the building stock in different countries at a regional level and the most impactful solutions.
- Priority should be given to studying the cost-effectiveness of the various programmes that have been implemented around the world to guide future programmes.

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Appendix A- Interviewed experts identified anonymously by country

Table A 1 - Interviewed experts identified anonymously by country.

Country	Expert	Country	Expert
Croatia	1	Slovenia	16
Germany	2	Slovakia	17
Spain	3	Bulgaria	18
Spain	4	Cyprus	19
France	5	Scotland	20
Italy	6	Northen Ireland	21
Italy/Spain	7	United Kingdom	22
Italy	8	New Zealand	23
Ireland	9	Australia	24
Lithuania	10	Scotland	25
Wales	11	The Netherlands	26
Poland	12	Scotland	27
Romania	13	Greece	28
Romania	14	Greece	29
Romania	15	Portugal	30

Appendix B - Description of programmes under study

Table B 1 - Renovation schemes in Australia.

 Australia				
Solar Homes Program				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Efficiency	Regional level	Between $1.000 and $2.950	2018 – 2023	[202]
Target Group		**Typologies**		
General population from Victoria		Electricity production Domestic water systems		

Table B 2 - Renovation schemes in Austria.

Austria

„raus aus Öl und Gas“ für Private 2021/2022 [Buildings renovation campaign 2021/2022]				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Efficiecy	National level	Up to 50% of eligible costs	2021-2022	[210]
Target Group		**Typologies**		
(Co-)owners, persons with right to build or tenants of one/two single-family houses.		Heating or/and Cooling equipment		

Table B 3 - Renovation schemes in Belgium.

Belgium

Primes énergie - Régime 2015-2019 [Energy allowances - 2015-2019 scheme]				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Efficiency	Regional level	Up to 70% of eligible costs	2015-2019	[212], [213]
Target Group		**Typologies**		
General population with own properties.		Insulation Heating or/and Cooling equipment Domestic water systems Energy Services		

Table B 4- Renovation schemes in Bulgaria.

Bulgaria

Energy Efficiency of Multi-Family Residential Buildings National Programme				
Scheme focus	Schemes level	Funding	Years	Links

Energy Efficiency	National level	Total funding	2015-2016	[215]
Target Group		Typologies		
General population		Implementation of EEMs as prescribed for the building in the energy efficiency audit Activities on structural reconstruction Insulation Energy Services		

Table B 5 - Renovation schemes in Croatia.

Croatia

Programa energetske obnove višestambenih zgrada [Energy renovation programme for high-rise buildings]				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Efficiency	National level	Maximum of 80% of the financing	2022-2024	[217]
Target Group		**Typologies**		
General population		Insulation Ventilation Windows Heating or/and Cooling equipment Electricity production		
Programmeuklanjanja energetskog siromaštva [Energy poverty reduction programme]				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy poverty	National level	Total funding	2021-2025	[217]
Target Group		**Typologies**		
Vulnerable households		Other measures		

Table B 6 - Renovation schemes in Cyprus.

Cyprus

Grand Schemes for Energy Efficiency and Renewable Energy Sources				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**

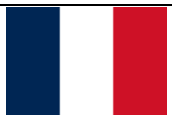
Energy Efficiency/energy Poverty	National level	Up to 50% of eligible costs.	2022-2023	[218], [311]
Target Group		**Typologies**		
General population		Insulation Electricity production		

Table B 7 - Renovation schemes in England.

England

The Boiler Upgrade Scheme				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Efficiency	National level	£5000- £6000	2022-2025	[220], [221]
Target Group		**Typologies**		
General Population		Heating or/and Cooling equipment		

Table B 8 - Renovation schemes in France.



France

Eco-prêt à taux Zéro [Zero rate eco-loan]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Benefit from an interest-free loan of up to €30,000 to finance eco-renovations	2009 - 2023	[223]
Target Group		Typologies		
General population		Windows Insulation Heating or/and Cooling equipment Domestic water systems		
Ma Prime Renov [My Renov Reward]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Poverty	National level	Financing of up to 35% to 50% of the total cost	2020 – 2023	[228]

Target Group	Typologies
Modest and very modest households with their own residence	Windows Solar protection Insulation Heating or/and Cooling equipment Domestic water systems Energy Services Ventilation

Table B 9 - Renovation schemes in Germany.

Germany

Bundesförderung für effiziente Gebäude (BEG WG) [Federal Promotion of Efficient Buildings - Residential Buildings]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Up 25% funding	2021- 2023	[231], [312]–[314]
Target Group		Typologies		
General population with own dwellings.		Insulation Windows Solar protection Doors Heating or/and Cooling equipment Domestic water systems Ventilation Electricity production Lighting installation Monitoring systems		

Table B 10 - Renovation schemes in Greece.

Greece

Exikonomo-Autonomo [I am saving]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Maximum eligible budget of EUR 80 000	2020-2021	[235], [236]

Target Group	Typologies
General population living in their own dwelling.	Insulation Windows Heating or/and Cooling equipment Domestic water systems Electricity production

Table B 11 - Renovation schemes in Ireland.

Ireland

Better Energy Warmer Homes Scheme (BEWHS)				
Scheme focus	Schemes level	Funding	Years	Links
Energy Poverty	National level	Total funding	2002-2023	[237], [241], [242], [315], [316]
Target Group		Typologies		
Owners and co-owners of dwellings living in them and receiving state support.		Heating or/and Cooling equipment Ventilation Insulation Lighting installation Energy Services		
Better Energy Homes Scheme (BEH)				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Between 800€ - 8 000€	2009-2023	[246], [247]
Target Group		Typologies		
Owners and co-owners of dwellings living in the same area.		Insulation Electricity production Domestic water systems Heating or/and Cooling equipment Energy Services		
National Home Energy Upgrade Scheme				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Between 800€ - 8 000€	2022-2023	[248]
Target Group		Typologies		
General population with own properties.		Insulation Domestic water systems Electricity production Heating or/and Cooling equipment Ventilation Energy Services		

Table B 12 - Renovation schemes in Italy.

Italy

Eco Bonus				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Between 50-90% of the total costs	2007- 2023	[251], [252]
Target Group		Typologies		
Homeowners or co-owners of dwellings, condominiums, and socially useful non-profit organisations.		Structure measures Insulation Windows Solar protection Heating or/and Cooling equipment Domestic water systems Monitoring systems		
SuperBonus 110%				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	110% of funding	2020-2025	[253]
Target Group		Typologies		
Homeowners or co-owners of dwellings, condominiums, and socially useful non-profit organisations.		Insulation Heating or/and Cooling equipment Windows Electricity production Domestic water systems Structure measures Other measures		

Table B 13 - Renovation schemes in Lithuania.

Lithuania

Daugiabučių namų atnaujinimo (modernizavimo) programa [Multi-apartment Building Renovation (Modernization) Programme]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency/Energy Poverty	National level	Total funding for low-income families.	2004-2023	[256], [259], [260]
Target Group		Typologies		

General population.	Heating or/and Cooling equipment Domestic water systems Electricity production Lighting installation Ventilation Insulation Windows Other measures Energy Services

Table B 14 - Renovation schemes in New Zealand.

New Zealand

Warmer Kiwi Homes programme				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Poverty	National level	Up to 80% of total costs	2021-2022	[262]
Target Group		**Typologies**		
Low-income homeowners.		Insulation Heating or/and Cooling equipment		

Table B 15 - Renovation schemes in Northern Ireland

Northern Ireland

Affordable Warmth Scheme				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Poverty	National level	Total funding up to £10 000	2001-2023	[264]
Target Group		**Typologies**		
Low-income households.		Insulation Heating or/and Cooling equipment Windows Ventilation		

Table B 16- Renovation schemes in Poland.

Poland

Czyste powietrze [Clean Air programme]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Between PLN 30 000 and PLN 69 000	2018 – 2029	[317]
Target Group		Typologies		
Owner or co-owner of a single-family dwelling.		Insulation Windows Doors Heating or/and Cooling equipment Ventilation Energy services		
Stop Smog				
Scheme focus	Schemes level	Funding	Years	Links
Energy Poverty	Anti-pollution municipalities	70% co-financing	2019 - 2028	[267]
Target Group		Typologies		
Municipalities; Districts; Inter-municipal association; Metropolitan Union in the Province of Silesia.		Insulation Windows Doors Ventilation Heating or/and Cooling equipment Domestic water systems Electricity production Monitoring systems Structure measures Energy Services		

Table B 17 - Renovation schemes in Portugal.

Portugal

Vale Eficiência [Efficiency Voucher]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Poverty	National level	Total funding	2021-2025	[270]

Target Group	Typologies
Economically vulnerable families in a situation of potential energy poverty, are eligible for the social electricity tariff (TSEE).	Windows Solar protection Insulation Doors Heating and Cooling equipment Domestic water systems Electricity production

Edifícios + Sustentáveis II [Sustainable Buildings II]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Up to 85% for each type.	2021-2022	[274]

Target Group	Typologies
Individuals who prove their ownership of the intervened property, including owners, co-owners, or the head of a couple of undivided inheritance.	Windows Solar protection Insulation Doors Heating and Cooling equipment Domestic water systems Electricity production Water efficiency solutions Structure Measures

Table B 18 - Renovation schemes in Romania.

Romania

Casa Eficient Energetic				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Efficiency	National level	Up to 60% of the total costs	2020	[275]

Target Group	**Typologies**
General population	Insulation Domestic water systems Windows Ventilation Lighting installation Heating or/and Cooling equipment

Table B 19 - Renovation schemes in Scotland

Scotland

Warmer Homes Scotland				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Poverty	National level	Total funding	2015-2023	[276]
Target Group		**Typologies**		
Vulnerable private sector households (tenants or owner-occupiers)		Insulation Heating or/and Cooling equipment Electricity production Domestic water systems Energy Services		
Home Energy Scotland Grant and Loan				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Efficiency	National level	Up to 75% of funding	2023	[277]
Target Group		**Typologies**		
General population		Windows Insulation Doors Heating or/and Cooling equipment Electricity production Domestic water systems Energy services		

Table B 20 - Renovation schemes in Slovenia.

Slovenia

ProgrammeZERO500 [ZERO500 programme]				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Poverty	National level	100% of funding	2022-2023	[278]
Target Group		**Typologies**		
Vulnerable citizens living in buildings suitable for energy refurbishment.		Insulation Windows Doors Ventilation		

	Domestic water systems Heating or/and Cooling equipment Energy Services

Table B 21 - Renovation schemes in Spain.

Spain

Programa Rehabilitación Energética de Edificios [Energy Rehabilitation of Buildings Programme]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Up to 35% of eligible costs.	2020-2021	[280]
Target Group		Typologies		
General population Communities of owners Operating companies Energy service companies Government entities		Insulation Windows Solar Protection Heating or/and Cooling equipment Domestic water systems Lighting installations Structure Measures Electricity production Monitoring systems		
Programa de ayudas para actuaciones de rehabilitación energética de edificios existentes II [Subsidy programme for the energetic renovation of existing buildings]				
Scheme focus	Schemes level	Funding	Years	Links
Energy Efficiency	National level	Up to 70% of eligible costs.	2018	[282]
Target Group		Typologies		
General population Communities of owners Operating companies Energy service companies		Insulation Windows Solar Protection Lighting installations Domestic water systems Heating or/and Cooling equipment Structure Measures Electricity production Monitoring systems		

Table B 22 - Renovation schemes in the Netherlands.

The Netherlands

Duurzame Energie en Energiebesparing (ISDE) [Investment subsidy for sustainable energy and energy saving]				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Efficiency	National level	Between 20 and 30% of funding	2022 - 2030	[284], [285].
Target Group		**Typologies**		
General population.		Insulation Heating or/and Cooling equipment Domestic water systems Other measures		

Table B 23 - Renovation schemes in Wales.

Wales

Warm Homes Programme Nest				
Scheme focus	**Schemes level**	**Funding**	**Years**	**Links**
Energy Poverty	National level	Total funding	2011-2023	[286]
Target Group		**Typologies**		
Low Income households.		Insulation Heating or/and Cooling equipment Water efficiency solutions Lighting installation		