Universidade do Minho
Escola de Engenharia

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Implementation of Building Renovation Passports for Low-Income Households in Portugal

dezembro de 2024

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STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.
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RESUMO

A União Europeia (UE) ambiciona alcançar a descarbonização total do sector da construção até 2050. A revisão da Diretiva relativa ao Desempenho Energético dos Edifícios (EPBD) em 2024 incluiu o Passaporte para a Renovação de Edifícios (PRE) na legislação como ferramenta essencial para acelerar as taxas de renovação, e cumprir os objetivos climáticos e energéticos da UE. Renovar 97% do parque edificado atual requer aumentar a taxa anual de renovações profundas de 1,2% para 2-3%. As renovações profundas melhoram significativamente a eficiência energética e são essenciais para atingir este objetivo. No entanto, os proprietários de edifícios enfrentam obstáculos como a dificuldade em obter financiamento e a falta de conhecimentos sobre as medidas a aplicar e a sua sequência.

Os Certificados Energéticos podem, potencialmente, ajudar a ultrapassar os obstáculos à renovação dos edifícios. No entanto, a sua aceitação e relevância no mercado é ainda limitada . Os PRE podem ajudar a ultrapassar este desafio, fornecendo informações e orientações que permitam aos proprietários melhorar a eficiência energética dos seus imóveis e, simultaneamente, reduzir as emissões de gases de efeito de estufa. Os PRE oferecem um roteiro de renovação passo a passo a longo prazo, desenvolvido com base numa auditoria energética ao edifício, respeitando os critérios e indicadores de qualidade específicos estabelecidos, e em colaboração com os proprietários. A implementação gradual de medidas de renovação pode ser especialmente vantajosa para casos de pobreza energética, que, pelas suas características sociais e económicas, beneficiariam de soluções ajustadas às suas necessidades específicas.

Este estudo analisa a implementação do PRE a quatro agregados familiares de baixos rendimentos em Portugal através de planos de renovação que consideram as necessidades específicas e o contexto de pobreza energética em que se inserem. Foram desenvolvidos planos de renovação personalizados para cada agregado familiar, que incluem um guia passo-a-passo pormenorizado, descrevendo-se as medidas necessárias a tomar, o consumo de energia esperado, os custos associados e os níveis de conforto previstos. O PRE facilita a implementação gradual de medidas, distribuindo o investimento financeiro ao longo de anos, tornando o processo mais acessível. Além disso, permite identificar oportunidades para otimizar o uso de energia, melhorar o conforto térmico e a qualidade do ar. A análise comparativa entre os passos propostos e as preferências dos proprietários apoia decisões informadas, alinhando os objetivos de eficiência energética com as expectativas. O PRE pode ser uma oportunidade para assegurar uma transição energética e climática mais justa e inclusiva.

Palavras-Chave: Pobreza Energética, Eficiência Energética, Passaporte de Renovação de Edifícios, Certificados Energéticos.

ABSTRACT

The European Union (EU) has set an ambitious goal of achieving full decarbonisation of the building sector by 2050. The Energy Performance of Buildings Directive (EPBD) revision in 2024 incorporated the Building Renovation Passport (BRP) into the legislation as a key tool to accelerate renovation rates to meet the EU's climate and energy targets. To undertake the unprecedented task of renovating 97% of the current building stock, increasing the annual deep renovation rate from 1.2% to 2-3% is crucial. Deep renovations that significantly enhance energy efficiency are essential to meet this target. However, building owners face obstacles such as difficulty obtaining financing and a lack of knowledge about the measures to be applied and their sequence.

Energy Performance Certificates (EPCs) can potentially overcome barriers to building renovation. However, their limited market penetration hinders their relevance for building owners. BRPs can help tackle these challenges by offering detailed information and guidance to enable property owners to enhance their properties and lower greenhouse gas emissions. BRPs offer a long-term step-by-step renovation roadmap based on an on-site energy audit meeting specific quality criteria and indicators established in consultation with building owners. The gradual implementation of renovation measures can be particularly beneficial for cases of energy poverty, where social and economic characteristics would benefit from solutions tailored to their specific needs.

This study examines the implementation of the BRP for four low-income households in Portugal by creating renovation plans that consider each household's specific needs and energy poverty context. Customised renovation plans were developed for each household, including a detailed step-by-step guide describing the necessary measures, expected energy consumption, associated costs, and anticipated comfort levels.

The BRP presents the necessary steps to improve the building's energy efficiency, contributing to its occupants' better quality of life. This tool enables the gradual implementation of measures, spreading the financial investment over several years and making the process more accessible. Furthermore, it facilitates identifying opportunities to optimise energy use, improve thermal comfort, and improve indoor air quality. Through a comparative analysis between the proposed steps and the owner's preferences, the passport supports informed decision-making, aligning energy efficiency goals with the owners' expectations. The BRP presents an opportunity to ensure a fairer, more inclusive energy and climate transition.

Keywords: Energy Poverty, Energy Efficiency, Step-by-step Renovation, Building Renovation Passport, Energy Performance Certificates.

TABLE OF CONTENTS

1. INTRODUCTION 1

1.1 Context 1

1.2 Goals 3

1.3 Dissertation Structure 4

2. STATE OF THE ART 5

2.1 Climate Change 5

2.1.1 Context 5

2.1.2 Building Sector 6

2.2 European Policies 8

2.3 Accelerating Deep Renovations 11

2.3.1 Renovation Wave 12

2.3.2 The Importance of the Energy Performance of Buildings Directive 13

2.4 Energy Efficiency IN Renovations 16

2.5 Energy Poverty 18

2.5.1 Context and Definitions 18

2.5.2 Energy Poverty Mitigation 20

2.5.3 Energy Poverty Mitigation in Portugal 20

2.5.4 Energy Poverty Indicators 23

2.6 Building Renovation Passport 26

2.6.1 From the Energy Performance Certificate to Building Renovation Passport 26

2.6.2 Building Renovation Passport 28

2.6.3 iBRoad2EPC 30

3. METHODOLOGY 40

3.1 Case Study 41

3.2 On-site-visits 43

3.3 User Profile 44

3.4 technical data 46

3.5 Definition of the Renovation Strategies 46

3.6 Calculations for Renovation Scenarios 48

3.7 Creation of the Building Renovation Passport 49

4 CASE STUDY CHARACTERISATION 52

5 RESULTS EVALUATION 60
5.1 CURRENT STATE 60
5.2 RENOVATION STRATEGY 61
5.2.1 LANDLORD´S RENOVATION SCENARIO 63
5.2.2 PASSIVE THERMAL COMFORT RENOVATION SCENARIOS 65
5.2.3 IBROAD2EPC RENOVATION STRATEGY 68
5.3 ENERGY SAVINGS 75
5.4 INVESTMENT COSTS 78
5.5 INDOOR ENVIRONMENTAL QUALITY 79
5.6 IBROAD2EPC PASSPORT 82
6. DISCUSSION AND MAIN FINDINGS 87
7. CONCLUSIONS 91
7.1 CONCLUSIONS 91
7.2 FUTURE WORK 93
REFERENCES 95

LIST OF FIGURES

Figure 1- Observed widespread and substantial impacts and related losses and damages attributed to climate change 6

Figure 2- Devastating floods hit Central and Eastern Europe in September 2024 © Sergei Gapon/AFP 8

Figure 3- Climate Policy - nZEB Ready provided by LNEG training course , 2024 9

Figure 4- The European Green Deal, European Commission (European Green Deal, 2019) 10

Figure 5- Renovation Wave Priorities, European Commission 12

Figure 6- Summary of requirements relevant to the residential trajectory – Adapted from "THE EPBD DECRYPTED", BPIE, 2024 16

Figure 7- Population unable to keep home adequately warm by poverty status- EU-SILC survey, 2023 Eurostat (Statistics | Eurostat, n.d.) 21

Figure 8- Share of total population living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor - EU-SILC survey, 2023 Eurostat (Statistics | Eurostat, n.d.) 21

Figure 9- EPC classes –"The EPBD decrypted: a treasure chest of opportunities to accelerate building decarbonisation", 2024 27

Figure 10- Mandatory elements for building passports – EPBD - Directive (EU) 2024/1275 of the European Parliament and of the Council- ANNEX VIII 30

Figure 11- Definition of a iBRoad2EPC Passport - Adene, 2024 31

Figure 12- Overview page of the iBRoad2EPC online output form - iBRoad2EPC ('iBRoad2EPC', 2023) 32

Figure 13- Page 2 of the iBRoad2EPC output form presents detailed information for each renovation step - iBRoad2EPC ('iBRoad2EPC', 2023) 32

Figure 14- Five steps to issue the iBRoad2EPC - iBRoad2EPC ('iBRoad2EPC', 2023) 33

Figure 15- Checklist iBRoad2EPC- Document provided by ADENE 34

Figure 16- Blank template iBRoad2EPC – Document Provided by ADENE 35

Figure 17- Preview of the iBRoad2EPC: overview page for building owners ('iBRoad2EPC', 2023) 37

Figure 18- iBRoad2EPC Assistant: The overview includes all renovation steps and the measures contained in 38

Figure 19- Dissertation flowchart 40

Figure 20 - Site plan for the case study houses (Houses nº 1, 3, 5 and 13) 42

Figure 21- Number of classic buildings by construction period, 2021 43

Figure 22- Proportion of conventional dwellings occupied as a usual residence by the owner, 2021 INE, Recenseamentos da População e da Habitação- (INE, 2024) 43

Figure 23- Recommendation for the next step iBRoad2EPC- House nº 4- iBRoad2EPC Platform provided by ADENE 50

Figure 24 Overview of the iBRoad2EPC document BRP of House nº 3- iBRoad2EPC Platform provided by ADENE 51

Figure 25- Location of the case study- Google maps 52

Figure 26- Portugal's climate zones in Winter and Summer- Dispatch (extract) n.º 15793-F/2013 53

Figure 27- Ground floor plan – Houses nº 1, 3, 5 and 13 54

Figure 28 – First-floor plan – Houses nº 1, 3, 5 and 13 54

Figure 29 - Second-floor plan – Houses nº 1, 3, 5 and 13 55

Figure 30- Houses nº 1(left) and House nº 3 (right) 56

Figure 31- House nº 5 (left) and House nº 13 (right) 58

Figure 32 - IEQ module - House nº1 80

Figure 33- IEQ module - House nº3 80

Figure 34- IEQ module – House nº 5 81

Figure 35- IEQ module – House nº 13 81

Figure 36 – House nº 1 Preview of the iBRoad2EPC: overview page for building owners 82

Figure 37 - House nº 1 Output page of the Energy Demand module in the online version in the output document of iBRoad2EPC 83

Figure 38- House nº 3 Preview of the iBRoad2EPC: overview page for building owners 83

Figure 39- House nº 3 Output page of the Energy Demand module in the online version in the output document of iBRoad2EPC..... 84

Figure 40 - House nº 5 Preview of the iBRoad2EPC: overview page for building owners 84

Figure 41 - House nº 5 Output page of the Energy Demand module in the online version in the output document of iBRoad2EPC..... 85

Figure 42- House nº 13 Preview of the iBRoad2EPC: overview page for building owners 85

Figure 43- House nº 13 Output page of the Energy Demand module in the online version in the output document of iBRoad2EPC..... 85

LIST OF TABLES

Table 1- The new Energy Performance of Buildings Directive (EPBD): main provisions and challenges - ADENE 2024 14

Table 2- Article 2- Definitions Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 15

Table 3- Article 2- EPBD Definitions - Directive (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024 29

Table 4 - Main characteristics of the households (U-value) 58

Table 5- Key indicators for measuring energy poverty in Portugal - ELPPE 60

Table 6- Population living in accommodation with problems related to sanitary facilities and the quality of physical structures - ICOR 61

Table 7- Existing Energy demand of the houses: EPCs 61

Table 8- Renovation measures 63

Table 9- Renovation measures considered by the landlord 64

Table 10- Results of the energy demand of the Households according to the landlord renovation strategy 65

Table 11- Renovation Strategies Incorporating Envelope Improvements and Ventilation Options - House n° 1 66

Table 12- Renovation Strategies Incorporating Envelope Improvements and Ventilation Options- House n° 3 66

Table 13- Renovation Strategies Incorporating Envelope Improvements and Ventilation Options- House n° 5 67

Table 14- Renovation Strategies Incorporating Envelope Improvements and Ventilation Options- House n° 13 67

Table 15- Renovation Strategy for House °1 69

Table 16- Energy needs House n° 1 70

Table 17- Renovation Strategy House n° 3 71

Table 18- Energy needs House n° 3 71

Table 19- Renovation Strategy- House n°5 72

Table 20- Energy needs House n°5 73

Table 21- Renovation Strategy House n°13 74

Table 22- Energy needs House n°13 74

Table 23- EPC Ratings for All Renovation Strategies by House 75

Table 24- Energy Savings House n°1 76

Table 25- Energy Savings House n°3 76

Table 26- Energy Saving House n° 5 77

Table 27- Energy savings in House n° 13 78

Table 28- Investment Costs 79

ABBREVIATIONS

BPIE	Buildings Performance Institute Europe
BRP	Building Renovation Passport
EC	European Commission
EE	Energy Efficiency
EED	Energy Efficiency Directive
ELPPE	Estratégia Nacional de Longo Prazo para o Combate à Pobreza Energética 2023-2050
EPBD	Energy Performance of Buildings Directive
EPC	Energy Performance Certificate
EPOV	Energy Poverty Observatory
EPVI	Energy Poverty Vulnerability Index
EU	European Union
GHG	Greenhouse Gases
ICOR	Inquérito às Condições de Vida e Rendimento 2023
IEA	International Energy Agency
IEQ	Indoor Environmental Quality
IPCC	Intergovernmental Panel on Climate Change
MEPS	Minimum Energy Performance Standards
MVHR	Mechanical Ventilation with Heat Recovery
NZEB	Nearly Zero-Energy Buildings
PRE	Passaporte para a Renovação de Edifícios
RED	Renewable Energy Directive
SME	Small Medium-sized Enterprises
SRI	Smart Readiness Indicator
UN	United Nations
UNFCC	United Nations Framework Convention on Climate Change
ZEB	Zero Energy Building

1. INTRODUCTION

This section provides the background for the topics addressed in this study and explains their significance for conducting the research. It also outlines the primary objectives and briefly describes the structure of the dissertation.

1.1 Context

The building sector confronts a significant transformative challenge: balancing the social responsibility of ensuring habitable living conditions with the imperative to reduce greenhouse gas emissions (GHG). Addressing energy poverty is crucial for building resilient communities and fostering a sustainable future (Della Valle et al., 2024). It is vital to adopt multi-faceted strategies that address structural inequalities and promote the active engagement of vulnerable citizens in the energy transition (Vandyck et al., 2023).

As part of Europe's commitment to the 1.5°C Paris Agreement target, the EU Renovation Wave strategy (Questions and Answers on the Renovation Wave, 2020) aims to accelerate deep renovation in the European Union (EU). Increasing the annual building renovation rate in the EU from 1.2% to 2-3% is essential to achieving a fully decarbonised and highly efficient building stock by 2050 while improving the citizens' quality of life.

To tackle energy poverty, the Renovation Wave aims to improve the energy efficiency of the worst-performing buildings, particularly those housing in vulnerable communities. Energy-efficient home renovations help reduce energy bills and enhance health, comfort, and overall well-being (Ahrentzen et al., 2016). These renovations provide a valuable opportunity for Europeans who struggle to afford adequate home heating.

Energy poverty, characterised by high energy costs, low income, and inefficient housing, can be addressed through retrofitting, financial support, and targeted protections. This complexity, driven by income levels, energy prices, and building efficiency, necessitates various policy solutions (DellaValle & Czako, 2022) (Bessa & Gouveia, 2023).

Despite recent policy efforts, such as the revision of the Energy Efficiency Directive (EED) by the European Commission in 2021 and the Second Recommendation on Energy Poverty 2023, an estimated 42 million people in Europe, constituting 9.3% of EU citizens, were unable to heat their homes in 2022 adequately. The situation worsened in 2023, with 10.6% of the population still facing this challenge. These data urge Member States to implement measures to address energy poverty and underscore the importance of empowering households to actively participate in the transition (Della Valle et al., 2024).

To meet their energy needs, vulnerable citizens may face difficulties when considering costly environmentally friendly actions, like investing in energy efficiency (Della Valle et al., 2024). Also, they face numerous obstacles when improving their properties' energy performance. In addition to financial hurdles, a common challenge is a lack of understanding about the required steps, where to start, and the order to implement measures (Fabbri, 2017). The energy poor are often less informed and may be prevented from choosing options that enable them to meet their energy needs while emitting less.

Energy Performance Certificates (EPC), as an informational tool, could fill that gap, providing clear and understandable information. The recommendations presented in EPCs are the first step towards buildings' better energy performance. However, EPCs do not provide personalised, well-planned renovation measures. The EU Member States have established national EPC schemes that significantly differ in scope and available information. Currently, they have limited user acceptance due to their low reliability. Most consider them a mere regulatory obligation with a low impact on the quality of the built environment (Grecchi et al., 2021). As a result, building owners do not typically consider EPCs a decisive factor in decision-making.

Recognising the potential impact of improved renovation recommendations, the Energy Performance of Buildings Directive (EPBD) (Directive 2018/844/EU) included an optional scheme in the long-term renovation strategy. This optional scheme, known as the Building Renovation Passport (BRP) concept, is designed to increase the rate of renovations across Europe. A BRP outlines a long-term step-by-step renovation roadmap to achieve deep renovation for a specific building. By examining initiatives from Germany, Flanders, and France, it was possible to conclude that this instrument can improve renovation rates (Sesana et al., 2019). The main concept behind these initiatives was that renovation plans are frequently limited by various factors, such as financial constraints, the need to minimise the duration of the renovation, discomfort during the works, and a lack of knowledge about the best available solutions.

The 2024 recast of the EPBD places a greater emphasis on BRPs in Article 12. It introduces stricter provisions for EPCs and establishes a framework for renovation passports as an optional tool to provide a clear plan for staged deep renovations. A renovation passport should be a structured methodology for staged deep renovations, enabling property owners and investors to plan interventions promptly and effectively and avoid potential lock-ins. The EPBD also acknowledges the potential for collaboration between renovation passports and EPCs, encouraging their joint preparation and issuance.

Della Valle and CzaKo (2022) argue that citizens must actively engage by making informed investment and consumption decisions for the energy transition to be fair and equitable. The authors note that the current lack of effective information mechanisms for promoting better consumption behaviours may stem from a one-size-

fits-all approach that fails to consider individuals' diverse needs and circumstances. Tailored energy advice is proposed to empower consumers by helping them identify the most suitable energy actions for their situation.

A crucial question is how to utilise BRP to assist vulnerable households in recognising their energy needs, developing decision-making capacity regarding their living conditions, and addressing the underlying injustices related to energy poverty and inequality.

Introducing a renovation passport could significantly improve the renovation of low-income housing. It would empower consumers by helping them make informed decisions about buildings with low quality and energy efficiency. This initiative would provide vital support by working together to create a renovation plan tailored to the specific needs of energy-poor households. By involving residents in the process, BRPs can help ensure that energy-efficient renovations are more tailored, equitable, and effective in tackling energy poverty.

1.2 Goals

This dissertation assesses the feasibility of implementing BRP to improve energy efficiency and building conditions for low-income households.

This will be achieved by developing tailor-made renovation scenarios for each household's needs and providing a step-by-step improvement plan outlining the measures to be taken, the expected energy use, the costs involved, and the expected comfort levels. By conducting this analysis, the objective is to demonstrate how a BRP can be a valuable tool for recommending ways to improve the energy performance of buildings. This can enhance the quality of life for occupants while also contributing to the broader goal of promoting sustainable development and addressing energy poverty.

The proposed framework aims to identify the best possible solutions for implementing individual renovation plans for four low-income single-household families in Porto. The methodology involves gathering data through initial contact with the owner and on-site visits to assess the present state of the building and occupants' needs. After this, renovation scenarios are defined and calculated, and a step-by-step roadmap is produced. The process intends to provide a comprehensive overview of the building's condition, enabling the identification of areas that require renovation. The roadmap should outline the necessary steps to enhance the building's energy performance, improve the quality of life for its occupants, and reduce its carbon footprint. This approach seeks to identify the best possible solutions for successfully executing renovation plans in similar settings.

In these circumstances, the main objective of this thesis is to understand how implementing Building Renovation Passports can facilitate and support deep renovation for low-income households.

Some specific objectives are identified as follows:

- Develop a staged deep renovation plan based on the specific needs and constraints of low-income households;
- Identify step-by-step renovation measures to achieve EPC levels complying with current and future regulatory requirements;
- Identify the technical and financial viability of the proposed roadmap to prevent lock-in effects;
- Identify energy savings and costs of the renovation measures;
- Assess the co-benefits of energy renovations, such as improving thermal comfort, indoor air quality, and occupant well-being.

1.3 Dissertation Structure

This dissertation is organised into seven sections.

The first section outlines the theoretical framework and structure of the dissertation.

Section 2 presents a comprehensive literature review, establishing the foundational context for the key themes explored in this research.

Section 3 details the methodology employed to address the research objectives.

Section 4 presents the case study, followed by the analysis of results in Section 5.

Section 6 provides an in-depth discussion of these findings.

Finally, Section 7 concludes the dissertation, summarising the study's main insights and contributions.

2. STATE OF THE ART

Addressing climate change and achieving the decarbonisation of the building stock are critical components of global efforts to mitigate greenhouse gas emissions and transition to a sustainable future. Buildings account for a significant share of energy consumption and carbon emissions, making them a key sector for intervention. This chapter provides a state-of-the-art overview of the challenges, strategies, and innovations driving the transformation of the building sector, focusing on policies, technologies, and practices aimed at enhancing energy efficiency and reducing the carbon footprint of buildings.

2.1 Climate Change

Worldwide, people are grappling with the challenge of climate change, which is widely recognised as one of the most pressing issues of our time (Campagna & Fiorito, 2022).

The significance of climate change becomes more pronounced as global temperatures continue to rise, increasing extreme weather events. The negative impacts on the environment and populations worldwide are escalating, resulting in more significant risks to human health and global ecosystems. These changes disproportionately affect vulnerable communities, who have historically contributed less to these issues (IPCC).

2.1.1 Context

The widespread adverse impacts have led to losses and damage to nature and people. This phenomenon has significantly impacted human health and well-being, manifesting in high mortality rates attributable to heat waves, floods, droughts, and storms. Climate change exerts profound economic consequences across climate-sensitive sectors, including agriculture, forestry, fisheries, energy, and tourism. Furthermore, it precipitates considerable destruction and loss of housing and infrastructure, adversely influencing property values and income levels. Urban infrastructure, encompassing transportation, water, sanitation, and energy systems, has faced significant challenges due to recent events (Figure 1). These challenges are expected to intensify because of factors such as overpopulation, urbanisation, increased energy consumption, material use, and poverty (World Economic Forum).

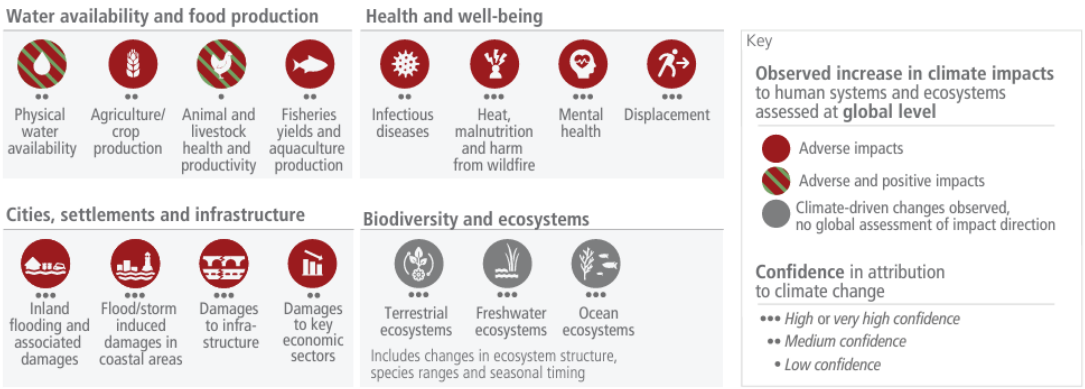


Figure 1- Observed widespread and substantial impacts and related losses and damages attributed to climate change

CLIMATE CHANGE 2023 Synthesis Report- Summary for Policymakers, IPCC 2023 (H. Lee & J. Romero, 2023)

It is widely accepted that anthropogenic activities, primarily through greenhouse gas emissions, have undeniably led to global warming. In 2023, total energy-related CO_2 emissions increased by 1.1%, reaching a record high of 37.4 Gt, according to the International Energy Agency, IEA. This increase in global temperatures fails to meet the steep reductions required by the Paris Agreement. Between 2011 and 2020, the global surface temperature rose by 1.1°C above the 1850-1900 average, as reported by the IPCC. Furthermore, 2023 saw a record high temperature, significantly impacting energy demand for heating and cooling and thus affecting energy sector emissions.

The world's population is projected to reach 9.1 billion by 2050, with most of this growth occurring in developing countries (Singh, 2019). This demographic expansion poses a significant threat to the urban environment and global economy. In addition, it is expected that by 2050, 68% of the global population will reside in urban areas, according to the United Nations (UN) (Department of Economic and Social Affairs). This underscores the urgent need to implement sustainable urban planning and development strategies that consider the impact of population growth on building energy consumption while simultaneously addressing the critical challenges posed by climate change (Taminiau et al., 2021).

2.1.2 Building Sector

Interconnected factors are deeply intertwined with urbanisation, encompassing key drivers of global greenhouse gas emissions and climate change such as population growth, economic activity, energy demand, building design and infrastructure, lifestyle choices, land-use practices, geographical location, and existing climate policies (Siddiketal.,2022).

In 2022, globally, buildings were responsible for 34% of global energy demand and 37% of CO_2 emissions related to energy and processes (Chatterjee et al., 2022). Building operations consume nearly 30% of global

energy and use about 55% of the world's electricity (Environment, 2024). The imperative for transformative action across all sectors to fulfil climate objectives is paramount within the building sector. This sector significantly influences the trajectory of global greenhouse gas emissions and has profound implications for future energy consumption patterns. Cooling and heating, the primary energy consumers in buildings, clearly illustrate the impact of climate change on energy use. With cooling demand increasing and heating demand decreasing, addressing cooling needs becomes critical to maintaining comfort in buildings facing rising temperatures (Bazazzadeh et al., 2021) (Li et al., 2023).

It is also essential to consider the construction industry's environmental impact, which arises from the entire lifecycle of building materials. This includes everything from the extraction and use of materials to their disposal and the creation and spread of pollutants. Specific resources are approaching a state of depletion as a direct consequence of climate change and the indiscriminate consumption of resources (Bazazzadeh et al., 2021). The world construction industry consumes 40-50% of all global building materials, totalling three billion tons of raw materials annually and contributing to 56% of its carbon footprint (Santamouris & Vasilakopoulou, 2021).

According to the 6th Synthesis Report from the IPCC, tackling climate change effectively requires a dual approach: adapting to current impacts while reducing greenhouse gas emissions. This strategy, known as climate-resilient development, aims for broader benefits, including securing access to affordable, clean energy as a critical element. Swiftly transitioning to renewable energy is crucial for energy security, affordability, and independence. It also limits the rise in global temperature and presents opportunities for economic growth, industrial progress, technological innovations, poverty reduction, and job creation (Environment, 2024). Therefore, it is crucial to focus on efforts within the building industry, highlighting its essential role in broader climate change mitigation strategies (Ürge-Vorsatz et al., 2020).

Considering buildings as tools to lower emissions and adapt to changing environmental conditions is crucial. With the construction boom in the developing world, emissions from buildings could double or triple by mid-century. Population growth, urban migration, and lifestyle changes are expected to increase building energy consumption. Immediate action is necessary to avoid building resource-intensive structures, as focused by the World Economic Forum. The transition towards low-emission energy in the construction sector encapsulates a crucial strategy for achieving sustainable development. This paradigm shift spurs economic growth and cuts global energy use and greenhouse gas emissions, aligning with key environmental and social goals (Ürge-Vorsatz et al., 2020).

As we move forward, understanding the global response to environmental challenges and exploring future directions in the fight against climate change is imperative. The European Union plays a key role in the fight against climate change by formulating and implementing various policies and strategies (Cifuentes-Faura, 2022a). The EU recognises the intrinsic significance of environmental protection in enhancing the health and well-being of its citizens and its potential as a catalyst for economic development. Over the years, it has developed policies and strategies, playing a crucial role in international climate negotiations. The urgency of action underscores the need for all nations to commit to combating climate change and assisting vulnerable countries and citizens.

2.2 European Policies

The accumulation of evidence regarding climate change and its implications has heightened society's consciousness (Figure 2). This increased awareness has prompted global governments to act, acknowledging the significant impacts on society, the economy, and the environment. The EU has been one of the most active in environmental protection, with the formulation of policies aimed at preserving the health and well-being of citizens and protecting natural resources. Environmental policies aim to green the member states' economies by addressing challenges like climate change, resource scarcity, pollution, and unsustainable consumption and production (Cifuentes-Faura, 2022b).



Figure 2- Devastating floods hit Central and Eastern Europe in September 2024 © Sergei Gapon/AFP (Parliament Reacts to Recent Extreme Weather Events in Europe | News | European Parliament, 2024)

Since the early 1990s, the EU and its member states have been at the forefront of addressing climate change in international policies. The EU has been found to exert leadership from the 1992 UN Framework Convention on Climate Change (UNFCCC) over the 1997 Kyoto Protocol to the 2015 Paris Agreement (Oberthür & Dupont, 2021).

The 2015 Paris Agreement, part of the United Nations Framework Convention on Climate Change (UNFCCC) (The Paris Agreement | UNFCCC, n.d.), significantly strengthened international efforts to tackle climate change. One hundred ninety-five countries and the EU adopted it to restrict the temperature increase to 1.5°C above pre-industrial levels. After the Paris Agreement, the EU made considerable efforts to decarbonise its building stock (Figure 3). Since almost 50% of EU final energy consumption is used for heating and cooling, with 80% of that used in buildings (Statistics | Eurostat, n.d.), the priority was to renovate the building stock with a focus on energy efficiency. This involved compelling the "energy efficiency first" principle and considering the deployment of renewables.



Figure 3- Climate Policy **-** nZEB Ready provided by LNEG training course, 2024

The European Green Deal endeavour can achieve zero emissions by 2050, positioning Europe as the first climate-neutral continent and a global leader in combating climate change. " It is a new growth strategy that aims to transform the EU into a fair and prosperous society, with a modern, resource-efficient and competitive economy where there are no net emissions of greenhouse gases in 2050, and economic growth is decoupled from resource use (European Commission, 2019).

The Green Deal (Figure 4) targets financing the shift towards a sustainable economy, ensuring a just transition in which no one is left behind, coupled with diplomatic engagement to accelerate sustainability transitions globally. As part of the EU Green Deal, The European Commission's Renovation Wave Strategy emphasises

the importance of doubling the renovation rate of buildings to enhance energy and resource efficiency in the construction sector. This move aims to support the circular economy, digitalisation, and climate resilience, ensuring affordable and energy-efficient solutions that reduce energy consumption and costs and alleviate energy poverty, improving the quality of citizens' lives. Additionally, it promotes job creation and the development of small and medium-sized enterprises (SMEs) (Claeys et al., 2024) (Haines & Scheelbeek, 2020). Since inefficient buildings increase vulnerability to cold spells and heat waves, the renovation wave strategy will enhance citizens' health and well-being.

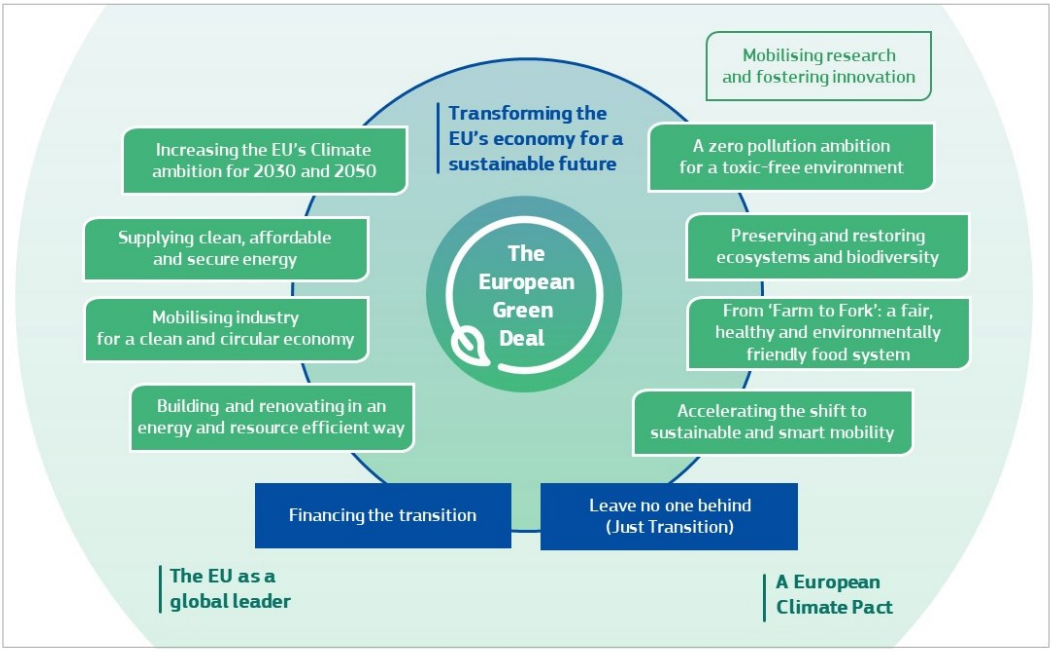


Figure 4- The European Green Deal, European Commission (European Green Deal, 2019)

In July 2021, the "Fit for 55 package" was introduced, along with legislative proposals detailing how the EU plans to achieve its goal of reducing greenhouse gas emissions by 55% by 2030. This package comprises a series of proposals designed to enhance existing legislation and introduce new initiatives, ensuring alignment between EU policies and climate objectives. The legislation package presents five new initiatives across various policy areas and economic sectors: climate, energy and fuels, transport, buildings, land use and forestry. The Fit for 55 initiative sets the EU on a path to reach its climate targets by 2030 in a fair, cost-effective, and competitive way. EU countries must consider energy efficiency in all relevant policies and significant investment decisions across energy and non-energy sectors. The proposal was further strengthened as part of the REPowerEU plan (2022) to decrease the EU's dependency on fossil fuel imports from Russia, accelerating the clean energy transition.

Energy efficiency is crucial in reducing energy consumption, central to the EU's climate ambitions, while enhancing energy security and affordability. The European Commission (EC) has proposed revising the Energy Efficiency Directive (EED) to achieve these goals, increasing the 2030 energy efficiency target from 32.5% to nearly 39%. It also includes the Renewable Energy Directive (EU) 2023/2413, which establishes a binding target of at least 42.5% to achieve a target of 45% for renewable energy sources in the EU's energy mix by 2030.

The proposed policy frameworks were built upon three fundamental principles related to energy. The first principle emphasises the need to guarantee an affordable, clean, and secure energy supply across the European Union. The second prioritises the renovation and upgrading of buildings in a manner that promotes both resource and energy efficiency. The third focuses on developing a fully digitalised and interconnected energy market within the EU, fostering the transition towards a circular economy (Rogulj et al., 2023).

The EPBD, the primary policy tool driving the decarbonisation of the building sector, is central to achieving these objectives.

The Clean Energy Package framework has strengthened relevant EU legislation, and along with the Fit for 55 package and Renovation Wave proposals, it is advancing the energy transition in Europe, particularly in building renovation. This progress emphasises the vital importance of building renovation in reaching Europe's sustainability goals, as highlighted by the Renovation Wave initiative introduced in the European Green Deal. Tackling Europe's decarbonisation challenge requires extensive adoption of nearly zero-energy buildings, integrating renewable energy into the building sector, and implementing deep renovation strategies (Gouveia et al., 2024).

2.3 Accelerating Deep Renovations

Deep energy renovations have emerged as a central strategy for improving energy efficiency and occupant comfort in recent years. Since introducing nearly zero-energy buildings (nZEB) standards in 2010, particular emphasis has been placed on the deep renovation of existing buildings (Gouveia et al., 2024).

The Renovation Wave aims to accelerate building deep renovations across the EU. It aims to improve the energy efficiency of public and private buildings, reduce greenhouse gas emissions, and create jobs in the construction sector (Questions and Answers on the Renovation Wave, 2020). The strategy involves mobilising

public and private investment, promoting innovative financing, and providing technical assistance to support the renovation project.

2.3.1 Renovation Wave

The Renovation Wave announced in the European Green Deal considered the building sector a pivotal strategy in the transition towards sustainability. It recognised the need for an urgent upgrade of building stock to address climate resilience, lift millions of Europeans from energy poverty, and ensure that buildings provide a healthy and affordable living and working environment.

The main focus areas (Figure 5) of the Renovation Wave are:

i. Tackling energy poverty and worst-performing buildings;

ii. Renovation of public buildings;

iii. Decarbonisation of heating and cooling.



Figure 5- Renovation Wave Priorities, European Commission

Despite the EU's well-developed climate policy framework, decarbonising the building stock and reducing greenhouse gases is still far from achieving climate neutrality by 2050, as BPIE's (Buildings Performance Institute of Europe) EU Buildings Climate Tracker reported in 2023. Renovation rates must significantly rise to meet the EU's climate neutrality ambitions. According to current building standards, approximately 75% of the building stock in the EU is considered energy-inefficient (Gokarakonda & Bankert, 2024). The goal is to cut building GHG emissions by 60% from 2015 and boost the annual deep renovation rate from 0.2% to 3% by 2030 (BPIE, 2023). Addressing the energy consumption of the building stock means drastically reducing its energy needs. For that objective, it is necessary to increase the renovation rates while ensuring deep energy renovations.

Although EU legislation has no legal definition, the European Commission has often used the proxy of '60% primary energy savings to determine what constitutes a deep renovation. Deep renovation is considered to improve indoor air quality and thermal comfort, positively impacting the well-being and health of occupants and improving productivity and educational performance. It lowers energy bills for vulnerable populations, mitigating energy poverty, as energy-poor households mostly occupy buildings with the worst energy performance. This process focuses on achieving maximum energy savings and high energy performance, ensuring that any remaining energy needs are met through renewable sources. When a one-step renovation is not feasible, deep renovation involves planning sequential upgrades, potentially guided by BRP. These passports detail the energy-saving and renewable energy measures to be implemented, preventing lock-in and may be tied to financial incentives (Deep Renovation, n.d.).

Strong, coordinated action from all stakeholders is needed to ensure a successful outcome. According to BPIE, the Renovation Wave involves various components, including step-by-step renovations, holistic renovations, targeted interventions for specific building segments and areas, sector-wide innovations, and customised solutions. Supportive legislation, enabling measures, and access to funding will be necessary to accompany these efforts.

Awareness of the significance of deep building renovation is growing rapidly, accompanied by emerging efforts to drive these transformations. These include policy initiatives, updated building regulations, fiscal incentives, and targeted training programs. The EPBD is the cornerstone of this.

2.3.2 The Importance of the Energy Performance of Buildings Directive

The EPBD remains the most critical legislative driver for change in the building sector. To encourage the large-scale renovation of EU existing buildings, the revised Energy Performance of Buildings Directive was adopted in April 2024 and published in the Official Journal of the EU on 8 May 2024 (Table 1).

The key provisions include an updated standard for new buildings focusing on whole-life carbon emissions and sustainability. Minimum Energy Performance Standards (MEPS) have been introduced to address the renovation of worst-performing non-residential buildings. Furthermore, a mandatory pathway has been established to gradually renovate residential buildings to enhance their energy performance. By 2050, the goal is to have an improved building stock supported by national renovation plans and measures to decarbonise heating and cooling systems. EPCs are enhanced, while a new EU framework promotes the adoption of renovation passports, helping to guide staged renovations. One-stop shops will play a stronger role in facilitating renovations, offering streamlined access to resources and support.

A more strategic and impactful financial framework is emphasised, focusing on ensuring the availability of funds and incentives for energy-efficient upgrades. Social fairness is emphasised, ensuring that all mandatory requirements and incentive provisions are equitable and accessible.

Table 1- The new Energy Performance of Buildings Directive (EPBD): main provisions and challenges - ADENE 2024

DIRECTIVE (EU) 2024/1275	**Key elements**
Renovation	a) Minimum energy performance standards (MEPS) for non-residential buildings b) Pathways for the progressive renovation of the residential building stock c) National Building Renovation Plans (established at the latest by 2026)
Framework	a) Enhanced energy certificates b) Renovation passports c) Financing and energy poverty d) One-stop-shops e) Definition of deep renovation f) Energy certificate databases
Decarbonisation	a) Zero-emission buildings as the new standard b) Installation of solar systems c) Life cycle emissions calculation for buildings d) Phase-out of incentives and installation of systems using fossil fuels
Modernisation & System Integration	a) Infrastructure for sustainable mobility b) Smart readiness indicator c) Indoor environmental quality d) Digitalization and national databases e) Building automation and control systems f) Integration and response to external signals

For this dissertation, it is essential to underline the strong emphasis on ensuring the social equity of all its provisions. The inclusion of legal definitions for terms such as "energy poverty" and "vulnerable households"

(Table 2) acknowledges the importance of the social dimension of the EPBD recast. The policies prioritise renovating the worst-performing buildings, often inhabited by those experiencing energy poverty. Alongside renovation requirements, the EPBD mandates that Member States offer targeted support to these groups through financial assistance or advisory services. Additionally, Member States must implement safeguards to protect citizens, especially tenants, and monitor the social effects of renovation and decarbonisation efforts (The EPBD Decrypted, 2024).

Table 2- Article 2- Definitions EPBD (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024

EPBD (EU) 2024/1275- Article 2- Definitions	
Vulnerable Households	means households in energy poverty or households, including lower middle-income households, that are particularly exposed to high energy costs and that lack the means to renovate the building that they occupy;
Energy Poverty (Article 2, point (52), of EPBD Directive (EU) 2023/1791)	means a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes.

The recast EPBD requires all Member States to establish a national trajectory for the progressive renovation of the residential building stock from 2020 to 2050. This trajectory aims to decrease the average primary energy use to a specified level (kWh/m²/year). Member States must ensure that the average primary energy use of the residential stock decreases by at least 16% between 2020 and 2030 and by at least 20 to 22% between 2020 and 2035. By 2040, 2045, and 2050, it should be equivalent to or lower than a nationally determined value derived from a progressive downward trajectory between 2030 and 2050. This should lead to a residential stock at Zero Energy Building (ZEB) level in 2050 (EPBD, 2024). To achieve at least 55% of the trajectory by renovating the 43% worst-performing residential buildings (Figure 6).

Therefore, it is crucial that a thorough transposition process is swiftly begun at the national level to accelerate building renovation and decarbonisation activities in the coming years and achieve the objectives of the Renovation Wave (The EPBD Decrypted, 2024).



Figure 6- Summary of requirements relevant to the residential trajectory – Adapted from "THE EPBD DECRYPTED", BPIE, 2024

2.4 Energy Efficiency in Renovations

Deep energy renovations that improve buildings efficiency are key to addressing Europe's decarbonisation challenge. Reducing consumption is crucial for lowering pollutant emissions and cutting energy costs for individuals and businesses. Therefore, it is proposed that mandatory energy efficiency targets at the EU level be increased to achieve an overall reduction of between 36% and 39% in primary and final energy consumption by 2030. In the building sector, energy-efficient measures can reduce energy consumption by up to 28% (Gouveia et al., 2024) (Chen et al., 2020).

Energy efficiency provides cost-effective ways to cut CO_2 emissions, decrease energy costs, and improve energy security. Investing in energy-efficient buildings and appliances can save money for households and lower emissions. Furthermore, applying circular economy principles, such as product downsizing, reusing, and recycling, is crucial for reducing greenhouse gas emissions (Hertwich et al., 2019).

Energy-efficient design significantly reduces building energy demand, lowering operational costs and greenhouse gas emissions. This subject encompasses three key aspects influencing overall energy consumption:

a) Improvement of building characteristics to reduce the building energy demand

Focusing on building orientation, shape, envelope, glazing, shading, passive heating/cooling, and natural ventilation from the start is crucial. A design prioritising energy efficiency cuts long-term costs by reducing energy use, outweighing the initial higher investment (Pacheco et al., 2012).

b) Use of energy-efficient equipment and technologies

Building service systems are the main energy consumers in a building, so many advanced technologies have been applied to enhance the energy efficiency of HVAC systems, air conditioning, electrical appliances, and DHW supply (Chen et al., 2020).

c) Occupant's behaviours

Technology alone will not achieve building energy savings goals, and occupants and their energy-related behaviour in buildings must be included in energy performance efforts. Several studies have highlighted the contribution of occupant behaviour to energy consumption (Chen et al., 2020) (Mylonas et al., 2024) (Zhang et al., 2018) (Yu et al., 2011). According to existing research findings, Zhang et al. (2018) estimate the energy-saving potential of occupant behaviour to be 10% to 25% for residential buildings.

A strategic shift towards electrification, especially in transportation and heating, marks a significant move away from fossil fuels. Santamouris and Vasilakopoulou (2021) argue that efficiency, electrification, behavioural change, and digitalisation could significantly impact global energy intensity. They also believe that the potential responses to these challenges and the policies implemented will greatly influence billions of people's present and future quality of life. These responses will broadly shape future socioeconomic paths and the scale of global growth.

Traditional energy sources, such as coal, oil, and natural gas, are finite and face depletion (Reddy et al., 2024). Integrating renewable energy technologies into the buildings is essential for addressing the impending scarcity of non-renewable resources and ensuring energy security for future generations. Additionally, it contributes to reducing greenhouse gas emissions and supports net-zero energy or carbon neutrality, facilitated by efficient building designs and energy systems (Ale, 2024). Solar and geothermal energy are critical in this integration, using technologies such as PV panels, heat pumps, and solar thermal collectors (Reddy et al., 2024).

Developing and enforcing policies that encourage low-emission strategies in the building sector is crucial to reducing CO_2 emissions and improving energy efficiency effectively. This involves setting efficiency standards,

prioritising the extensive renovation of existing buildings to improve their envelopes, and optimising heating and cooling solutions. These policies should also be adaptable to specific political and regional contexts.

Energy efficiency is seen as the most effective solution to alleviate energy poverty and counter the potential negative impacts of pricing measures. By using energy more efficiently and reducing consumption, Europeans

can enjoy lower energy bills, protect the environment, mitigate climate change, enhance their quality of life, decrease reliance on external oil and gas suppliers, and promote sustainable economic growth within the EU.

2.5 Energy Poverty

The EU has broadened the narrative of a just and fair energy transition. With energy poverty as a critical concept, it is essential to prioritise support for the most vulnerable groups and less resilient populations to ensure that all EU citizens can reap the benefits. The EU's support measures to tackle energy poverty mainly include improving energy efficiency, providing social tariffs, and promoting energy savings (In Focus, 2022). The energy crisis in the post-pandemic era has brought the topic of energy poverty to the forefront of economic policy debates.

The Commission Recommendation on Energy Poverty of 20 October 2023 acknowledges that energy poverty is a complex issue caused by three main factors: high energy costs related to household income, generally low-income levels, and poor energy efficiency of buildings and appliances (Maier, 2024). Individuals or communities in energy poverty face limitations in accessing reliable, affordable, and sustainable energy.

The problem of energy poverty is intricate and affected by numerous factors, such as household status, income, gender, knowledge, accessibility of electrical appliances, energy sources, and prices. Its impact on society can be far-reaching, affecting various sectors such as social, energy, housing, health, and the environment and increasing the risk of energy vulnerability.

Vulnerable and marginalised populations, including low-income families, the elderly, and those in low-quality housing, are disproportionately affected. Energy poverty is closely linked to social inequality, exacerbating existing disparities and creating energy underclasses. Additionally, it poses significant risks to human well-being, with inadequate access to heating and cooling leading to health issues and reduced thermal comfort (Jones & Reyes, 2023). Addressing energy poverty is a challenging task that requires a multifaceted approach.

2.5.1 Context and Definitions

Energy poverty is a multidimensional reality resulting from several factors: low incomes, difficulty accessing efficient, quality energy services, poor energy performance in homes, and low levels of energy literacy (European Commission: Energy Poverty, 2023).

Boardman (2009) defines energy poverty as the inability of households to afford basic energy needs for heating, lighting, cooking, and appliances due to insufficient income. Palmer, Macinnes, and Kenqay (2008) note that not all individuals experiencing income poverty are also experiencing energy poverty, and vice versa. According to Bouzarovki (2014), poverty can result from high energy prices, low household incomes, inefficient buildings and appliances, and specific household energy needs.

Thomson, Bouzarovski, and Snell (2017) suggest that household energy efficiency and poverty are closely connected. Energy poverty refers to the lack of access to modern energy services, which can have profound social and economic consequences. In contrast, household energy efficiency describes the energy required to generate a specific output level within a household. Improving household energy efficiency can address energy poverty and reduce its impact on vulnerable households.

Energy poverty is influenced by household status, income, gender, knowledge, appliance accessibility, energy sources, and prices. It has a broad impact, touching on social, energy, housing, health, and environmental sectors and heightening the risk of vulnerability to price hikes.

2.5.2 Energy Poverty Mitigation

Mitigating energy poverty requires effective measures and policies, such as providing financial assistance to vulnerable and marginalised social groups, reducing energy prices, and improving energy efficiency. Innovative solutions are being explored and developed to address energy poverty in the future. These include policy innovations, energy efficiency techniques, and sustainable building renovation (Gouveia & Barbosa, 2022). Assessments were conducted to better comprehend and tackle energy poverty, including evaluating indoor thermal comfort and energy use in vulnerable households (Dascalaki & Balaras, 2021). Research was conducted to investigate the health consequences of energy poverty (Haddad et al., 2019). Dascalaki (2021) highlights the importance of accurate energy savings estimates and occupant behaviour for achieving thermal comfort and energy efficiency. Research has shown that investing in social protection measures and increasing social protection benefits for vulnerable groups can effectively reduce energy poverty (Rodriguez-Alvarez et al., 2021).

In some EU countries, particularly in Eastern Europe, the energy cost has been rising faster than the net incomes of low-income households (Streimikiene et al., 2020). As a result, these households are finding it difficult to afford the energy needed for essential residential needs such as heating and lighting. Inadequate energy efficiency in buildings and appliances can further contribute to higher energy consumption, exacerbating the issue of energy poverty (Energy Poverty Mitigation in Europe, 2023).

Another critical obstacle in addressing energy poverty is the lack of information and awareness about energy-saving measures and the available support programs. Numerous households may not be familiar with energy-saving practices or financial assistance programs that can enhance energy efficiency and reduce energy expenses (Ritchie et al., 2023).

Lack of access to clean and sustainable energy sources can result in reliance on fossil fuels or inefficient energy sources, a hurdle for the economically disadvantaged.

Streimikiene et al. (2020) suggest that to address energy poverty, the following steps should be implemented:

1. Introduce and implement energy-efficient measures;
2. Educate low-income households about energy-saving practices and behaviours;
3. Develop new energy policies that are tailored towards reducing energy poverty.

Some authors argue that while major insulation upgrades are often required, individuals facing energy poverty typically lack the initial funding for these investments. In theory, energy advice is crucial for guiding homeowners on the appropriateness of substantial energy efficiency improvements and informing them about available financial support (Simcock & Bouzarovski, 2023).

Energy poverty should be addressed mainly by creating effective policies and encouraging synergies among policies in different fields (Aparisi-Cerdá et al., 2024).

2.5.3 Energy Poverty Mitigation in Portugal

According to estimates, a substantial portion of the Portuguese population, between 1.8 and 3 million people, is currently affected by energy poverty and its associated challenges. The latest data for the year 2023 shows that the percentage of the population unable to adequately heat their homes due to poverty in Portugal increased from 17.5% in 2022 to 20.8% in 2023 (Figure 7). Additionally, 29% of the population lives in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames or floors (Figure 8). These numbers reveal the urgency and scale of the problem in Portugal, one of the highest in the EU.

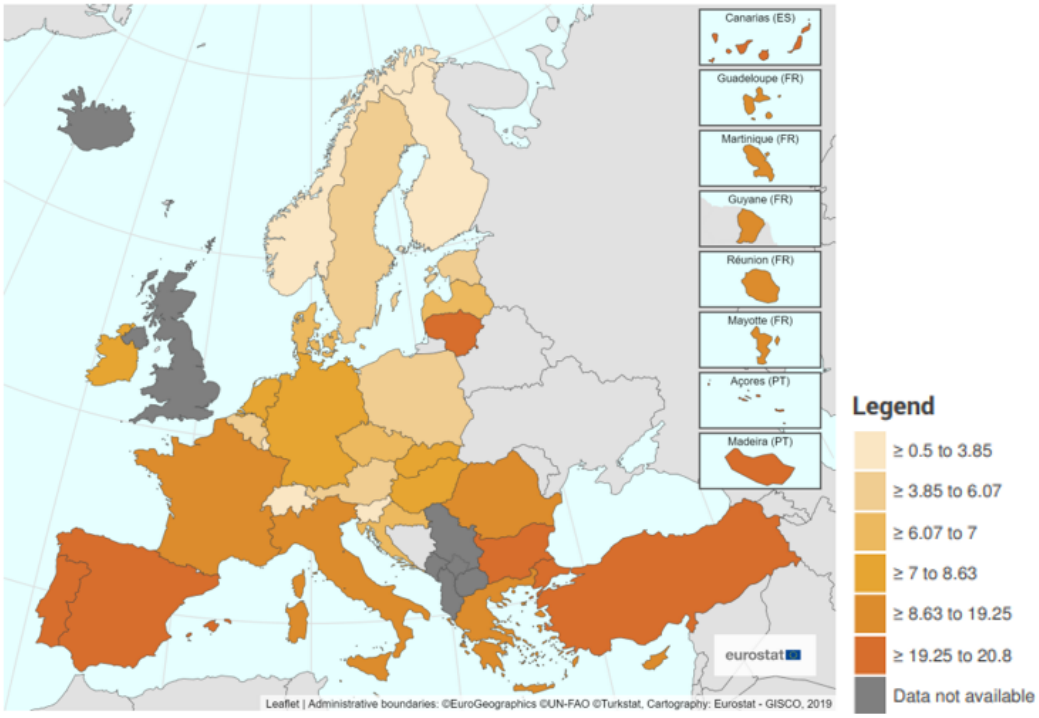


Figure 7- Population unable to keep home adequately warm by poverty status- EU-SILC survey, 2023 Eurostat (Statistics | Eurostat, n.d.)

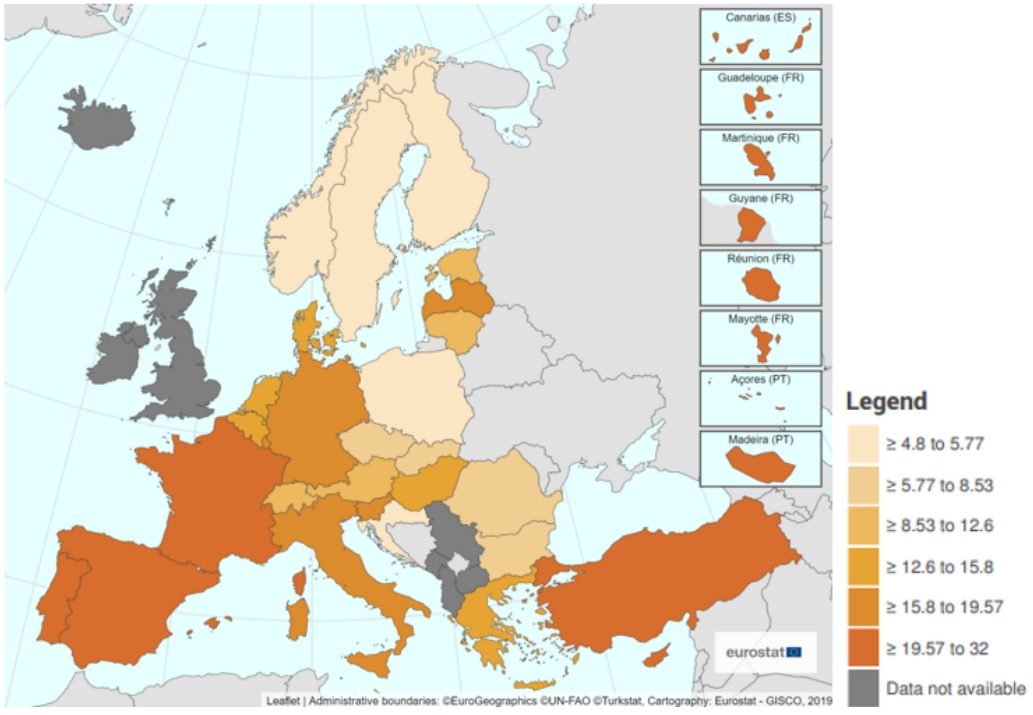


Figure 8- Share of total population living in a dwelling with a leaking roof, damp walls, floors or foundation, or rot in window frames of floor - EU-SILC survey, 2023 Eurostat (Statistics | Eurostat, n.d.)

In November 2023, Portugal approved the Long-term Strategy to Combat Energy Poverty 2023-2050 (ELPPE). This strategy aims to address this issue through a comprehensive and sustainable approach that leverages technology and innovation to improve energy efficiency and promote the use of renewable energy sources, thereby enhancing the well-being and quality of life of affected individuals and communities (Estratégia de Longo Prazo de Combate à Pobreza Energética, 2023).

ELPPE is structured around four strategic pillars that guide action, are interrelated, and complement each other:

1. Promote energy and environmental sustainability in housing by improving energy efficiency in households while simultaneously decarbonising energy consumption;
2. Ensure universal access to essential energy services, especially for vulnerable families, protecting those in energy poverty;
3. Encourage integrated territorial action, strengthening the action of local structures to support citizens and providing high-energy public housing;
4. Foster knowledge and informed action, enhancing the ability to identify households facing energy poverty, promoting energy literacy, fostering research and innovation, and supporting the training of professionals required for implementing rehabilitation, energy efficiency, and renewable energy solutions in homes.

ELPPE strategically works to eliminate energy poverty in Portugal by 2050, advocating for a just and inclusive energy and climate transition. The main objective is to improve energy efficiency and environmental sustainability in housing by enhancing energy use and reducing carbon emissions.

To increase the energy efficiency of housing, better construction techniques, materials, and efficient equipment must be used to reduce energy needs and enhance comfort. The following measures should be considered:

- refurbishment of the envelope;
- restoration of the glazed envelope;
- replacement of rotten elements and humidity reduction;
- efficient ventilation;
- efficient household appliances and lighting;

- water heating and water efficiency;
- efficient heating and cooling systems.

To achieve decarbonisation, it is essential to focus on reducing reliance on fossil fuels by integrating local renewable energy systems for electricity, heating, and cooling. This approach involves harnessing resources such as solar, wind, and geothermal energy to create decentralised energy solutions that are sustainable and resilient. Additionally, the electrification of energy use plays a pivotal role in this transition. To promote this energy transition, the Portuguese strategy focuses on:

- promoting self-consumption of renewable electricity;
- renewable energy communities;
- renewable heating and cooling;
- electrification of consumption.

Improving the energy efficiency of buildings through rehabilitation is a crucial part of the Portuguese strategy. It emphasises that energy renovation has numerous advantages in the context of the nation, including better health, increased work productivity, and appreciation of property value. Accurately assessing energy poverty is crucial to understanding the scope of the problem and evaluating policy impact at both national and regional levels (Gouveia et al., 2019). However, measuring potential cases of energy poverty using indicators that capture various aspects of the phenomenon is necessary to identify it.

2.5.4 Energy Poverty Indicators

Measuring energy poverty is crucial for evaluating the effectiveness of policies at both national and regional levels. Various indicators are used to assess this complex phenomenon, as energy poverty is a multidimensional concept that cannot be fully captured by a single measure (Energy Measures, 2020).

The EU Energy Poverty Observatory (EPOV) recommends employing consensual self-reporting indicators, which rely on individuals' perceptions of their energy needs, and expenditure-based indicators, which analyse energy spending relative to income. EPOV suggests combining these indicators to provide a more comprehensive understanding of energy poverty (EPAH, 2023).

There are four primary ways to identify energy poverty, according to the EPOV (EPAH, 2023). These approaches are as follows:

1. Identifying households that spend more than twice the national median on energy. It suggests that such households may prioritise energy over other essential expenses;
2. Identifying households whose energy expenses represent less than half the national median. It also identifies households that restrict their energy use and expenses below the necessary amount for fulfilling basic needs, which is also known as hidden energy poverty;
3. Households who reported being unable to pay utility bills on time within the past 12 months are considered to have arrears;
4. The inability to heat homes adequately is based on self-reported thermal discomfort and perceived energy poverty.

Many countries use additional indicators to supplement the ones used by the EPOV. These include the population living in poverty, the population living in households that cannot afford proper heating, households that qualify for social tariff, households whose energy expenses account for more than 10% of their total income, and households living in poverty whose energy expenses represent over 10% of their total income, among others (Energy Poverty Mitigation in Europe, 2023).

The Energy Poverty Vulnerability Index (EPVI) developed by CENSE - the Environment and Sustainability Research Centre of the Faculty of Science and Technology, Universidade Nova de Lisboa - has been updated annually since 2017. This index enables assessing and mapping the Portuguese population's vulnerability to energy poverty at the parish level in winter and summer. It combines an analysis of the energy performance of residential buildings, energy consumption in dwellings, and the socioeconomic characteristics of the inhabitants. The index helps to identify areas of vulnerability where intervention is a priority (Estratégia de Longo Prazo de Combate à Pobreza Energética, 2023).

According to the ELPPE, the key strategic indicators for measuring energy poverty in Portugal are as follows:

1. Population living in households unable to keep their homes adequately warm;
2. Population living in poverty and in households unable to keep their homes adequately warm;
3. Energy performance of dwellings;
4. Population living in dwellings with problems of infiltration, humidity or rotten elements;
5. Poverty-stricken population living in dwellings with problems of infiltration, damp or rotting elements;

6. Population living in dwellings that are not comfortably cool during the summer;
7. Population in households whose energy expenditure represents +10 % of total income;
8. Households in poverty whose energy expenditure represents +10 % of total income.

The Living Conditions and Income Survey (ICOR) by INE measured the proportion of the population living in dwellings with problems related to sanitary facilities and the quality of physical structures (ICOR, Portugal, 2023) according to these parameters:

i. dwelling with a leaking roof, damp walls, floors, or foundation, or rot in window frames or floors;
ii. no bath, shower or toilet inside the accommodation;
iii. insufficient natural light on a sunny day;
iv. fraction of residential buildings with energy class C or lower.

Energy poverty is a complicated issue that cannot be fully understood through income levels or other socioeconomic factors alone. Structural deficiencies, such as poorly constructed buildings and inadequate heating and cooling systems, significantly worsen energy poverty. To effectively address this problem, the EPVI can be utilised to identify targeted energy and social policies. These policies should prioritise improving energy efficiency and ensuring energy affordability in buildings, focusing on reducing energy demand while maintaining comfortable thermal conditions. Additionally, such policies should be reinforced by social incentives and subsidies provided by governing institutions, ideally implemented at the local or municipal level. Examples include energy efficiency upgrades, such as improved insulation and efficient heating systems, directly tackling energy demand and occupant comfort (Gouveia et al., 2019).

It is crucial to prioritise building renovation as a key strategy to address energy poverty and ensure that European legislation effectively tackles this pressing issue. The revised EPBD introduces specific provisions to support energy-poor and vulnerable households and individuals living in social housing. However, the process of renovating buildings remains complex and challenging to coordinate. To overcome these barriers, communities require enhanced support through local authorities and the implementation of robust financial and technical tools, such as the BRP.

2.6 Building Renovation Passport

The Renovation Wave strategy emphasises the importance of EPCs and BRPs as essential informational tools that can initiate and speed up the process of deep renovations. The 2024 EPBD recast introduces strict new rules for EPCs. It includes a framework for renovation passports, an optional tool to guide the step-by-step process of deep renovations. These renovation passports provide a structured plan, helping property owners and investors schedule improvements efficiently and avoid any limitations hindering future renovations. The EPBD also highlights the potential benefits of using renovation passports alongside EPCs and encourages their combined use and issuance.

2.6.1 From the Energy Performance Certificate to Building Renovation Passport

EPCs are a key tool for assessing and presenting buildings' energy performance, thereby essential for improving energy efficiency. They inform owners, occupants, and property developers about the building's condition, operating costs, energy consumption, and potential savings (Vivian Dorizas et al., 2022).

The EPC was introduced at the European level by the EPBD- 2002/91/EC (Directive 2002/91/EC EPBD, 2002). The certificate certifies the overall energy performance of a building and provides other parameters that allow for comparison with similar buildings in terms of type and use (Grecchi et al., 2021). This information is presented using a scale of letters commonly rated in Europe, usually ranging from A+(most efficient) to G (least efficient), and in Portugal, from A+ to F, along with practical recommendations for improvement (Nunes & Lopes, 2024). The legislation mandates EPCs for all property sales and rentals to reduce information asymmetry in the building market.

With the recast of Directive 2010/31/EU (Directive 2010/31/EU, 2010), the certification system for existing buildings was strengthened by including a mandatory report of recommendations that listed the improvement measures and their priorities. Each member state has transposed the Directive differently, resulting in some differences in the calculation method, parameters, and energy classification.

Based on research from the BPIE (Economidou et al., 2011) and other studies (Horowitz & Bertoldi, 2015), EPCs are a critical source of information regarding the energy performance of the EU's building stock. Moreover, EPCs possess the potential to serve as powerful tools for monitoring the energy performance of buildings and the impact of building policies over time. Additionally, they can facilitate the implementation of minimum energy requirements within the regulatory process (Sesana & Salvalai, 2018).

Former analyses of the impact of EPCs on the EU construction market have revealed a widespread lack of confidence in their effectiveness. Many view EPCs as a regulatory obligation that has little impact on the quali-

ty of constructed spaces (Grecchi et al., 2021). EPCs were considered ineffective in increasing renovation rates as they do not provide personalised recommendations for renovation options (Fabbri, 2017).

Despite various additional regulations, the expected results on existing buildings have not been achieved. Increasing the rate of energy-related renovations is not easy, given the many obstacles typical of the construction process. These obstacles typically include financial, technical, procedural, regulatory, and awareness-raising issues (Grecchi et al., 2021).

The recast EPBD 2024 introduces measures to make EPCs more precise, reliable, and visible. It establishes a standard template across all 27 EU Member States, featuring key energy use and GHG emissions indicators, with optional indicators such as charging points or indoor air quality controls. This could benefit building owners, buyers, tenants, financial institutions, and public authorities.

The 'A' rating will represent zero-emission buildings, while the 'G' rating will mark the worst-performing buildings in each country. Other buildings will be classified into the remaining categories, making the system simpler and easier to understand. This classification will help facilitate access to financing and can be adapted to each country's building stock. Additionally, Member States may introduce an 'A+' class for buildings that exceed zero-emission standards by producing more renewable energy on-site than they consume (Figure 9).

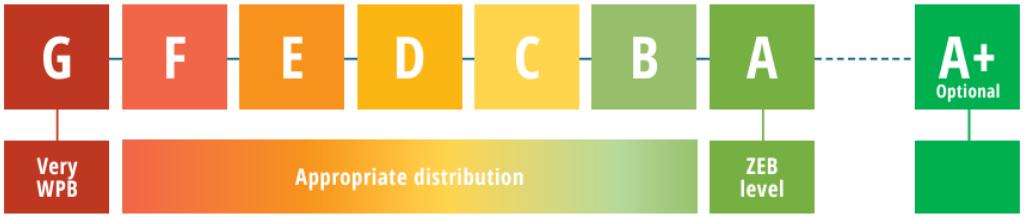


Figure 9- EPC classes – "The EPBD decrypted: a treasure chest of opportunities to accelerate building decarbonisation", 2024

The EPC infrastructure can be leveraged to introduce and encourage the use of BRPs. This may include offering additional training to building professionals who issue EPCs. Linking the BRP with current databases and registries can reassess existing schemes and enhance them to ensure that building owners receive current and personalised information that meets their needs. Building on established instruments like EPCs enables stakeholders to develop more appropriate tools for renovations over time.

2.6.2 Building Renovation Passport

The last EPBD revision recognises the potential connection between renovation passports and EPCs. Renovation passports can be integrated into national EPCs, turning the EPC into an instrument to provide clear renovation advice towards achieving deep energy renovations.

BRPs were first mentioned in 2018 under Article 2ª as an example of an optional scheme within the long-term renovation strategy. They aim to encourage cost-effective deep renovation of buildings, including staged deep renovation, and to support targeted cost-effective measures and renovations.

The BPIE defined BRP as a comprehensive renovation plan that spans a 15-20-year period (Fabbri et al., 2016). A BRP should involve analysing the entire building and recommending specific measures to be installed in a particular order, ensuring that future measures can be added without any issues during the renovation process. This tailored approach aims to simplify homeowners' typically convoluted and lengthy renovation process by presenting a detailed plan for renovating a building and reducing energy consumption through deep renovation as defined by EC (Grecchi et al., 2021).

The BRP aims to mitigate risks and increase investors' confidence by providing stakeholders, financial institutions, mortgage credit providers, investors and insurers access to critical building-related documentation and information. This supports investment decision-making, creates opportunities for innovation, and encourages the uptake of energy efficiency and sustainability measures. BRPs play a valuable role in boosting the availability of information to a wide range of market participants. They improve the quality assurance system for buildings and enhance the overall market for the construction industry (Fabbri, 2017).

In Europe, it is common for homeowners to renovate their homes gradually over a few years. However, this can lead to a phenomenon known as "lock-in," which means that current choices may limit future renovation options and hinder improving a building's energy efficiency and overall status. These challenges are made more complex by the distinctive features of each building, such as its construction history of alterations and present use, together with homeowners' diverse needs, preferences, and resources.

To effectively implement BRPs, specific barriers must be overcome, such as adopting a long-term outlook, involving customers, and considering the individual circumstances of each renovation project. Additionally, automation and flexibility play crucial roles in the success of a BRP. At the same time, personalised and reliable guidance is essential for encouraging customer participation and facilitating a shift towards clean energy (Sesana & Salvalai, 2018). Nevertheless, the benefits of BRPs, including decreased energy costs, enhanced

comfort and well-being, and reduced carbon emissions, make them an appealing choice for those dedicated to promoting sustainable lifestyles.

Despite the benefits of building renovation, many individuals find it overwhelming due to a lack of understanding regarding the appropriate measures to implement and their optimal sequencing. Furthermore, many perceive building renovation as a cumbersome process that requires extensive planning, is fraught with uncertainty regarding the efficacy of chosen measures, entails considerable dust, and can involve unreliable professionals. To overcome these challenges, it is crucial to possess a comprehensive understanding of the necessary measures and the order in which they should be implemented (Mariangiola Fabbri et al., 2018).

To steer the EU towards implementing the Renovation Wave and reducing the building stock's impact on climate change, Member States must revise and strengthen their EPC schemes and establish a clear framework for renovation passports (Gokarakonda & Bankert, 2024).

The recast EPBD 2024 considers that staged deep renovation can be a solution to address the high upfront costs and inconvenience for the inhabitants that may occur when renovating all at once. Staged deep renovation can allow for less disruptive and more financially feasible renovation measures. Renovation passports provide a clear plan for staged renovations (Table 3), helping property owners and investors determine the best timing and scope for each step. They should be promoted as a voluntary tool across all EU MS, ensuring they do not impose excessive burdens while providing financial support to vulnerable households wishing to renovate their buildings.

Table 3- Article 2- Definitions - EPBD (EU) 2024/1275 of the European Parliament and of the Council of 24 April 2024

EPBD (EU) 2024/1275- Article 2- Definitions	
Deep Renovation	means a renovation which is in line with the 'energy efficiency first' principle, which focuses on essential building elements, and which transforms a building or building unit: (a) before 1 January 2030, into a nearly zero-energy building; (b) from 1 January 2030, into a zero-emission building;
Staged Deep Renovation	means a deep renovation carried out in a maximum number of steps, asset out in a renovation passport.
Renovation Passport	means a tailored roadmap for the deep renovation of a specific building in a maximum number of steps that will significantly improve its energy performance;

The recast EPBD also includes a common EU framework for renovation passports, which further elaborates on the definition and describes the main renovation passport design features distributed between mandatory and optional elements (Figure 10).

The renovation passport must include (Annex VIII of Directive (EU) 2024/1275 of 24 April 2024):

- Information about the building's current energy performance
- A graphical representation of the roadmap and its respective steps for a deep renovation
- Information about relevant national requirements, such as minimum energy performance requirements for buildings, standards, and minimum energy performance rules
- A brief explanation of the optimal sequencing of the steps
- Information on each step, including:
  - the name and description of the renovation measures
  - an estimate of energy savings
  - an estimate of the reduction in GHG emissions
  - an estimate of savings on the energy bill
  - an estimate of the energy performance class after completion of the step
- Information about a potential connection to an efficient district heating and cooling system
- The share of individual or collective production and self-consumption of renewable energy
- General information on the available options to improve the circularity of construction products and reduce their greenhouse gas emissions throughout the entire life cycle, as well as on broader benefits related to health and comfort, indoor environmental quality, and improving the building's adaptability to climate change
- Information about available financing
- Information about technical advice and advisory services, including contacts and one-stop shops.

Figure 10- Mandatory elements for building passports – EPBD - Directive (EU) 2024/1275 of the European Parliament and of the Council- ANNEX VIII

2.6.3 iBRoad2EPC

iBRoad2EPC is a follow-up project to the iBRoad initiative between 2017 and 2020 (Mariangiola Fabbri et al., 2018). The iBRoad project developed and tested a model for the BRP. The primary goal of iBRoad2EPC is to bridge the BRP to the EPC and expand, enhance, and broaden their format and scope to encompass additional features, such as indoor environments and smart technologies ('iBRoad2EPC', 2023). The project also aims to make these tools applicable to multi-family and public buildings and improve their reliability, usefulness, and effectiveness to establish the next generation of EPCs that support Europe's decarbonisation efforts.

The iBRoad2EPC project (Figure 11), funded by the EU's Horizon 2020 programme, has developed a flexible, adaptable, modular model renovation passport. It also provides solutions that can be immediately applied to the transposition and/or implementation of several EU policy instruments, including the EPBD, the EED, and the Renewable Energy Directive (RED).

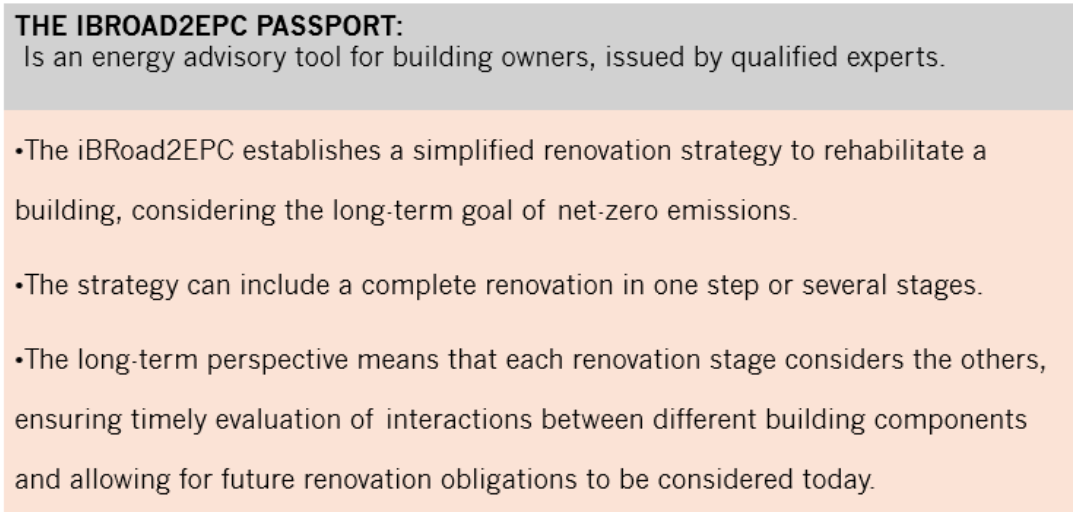


Figure 11- Definition of a iBRoad2EPC Passport - ADENE, 2024

The main objectives are:

- assess the needs, potential and practicability of merging the EPC with the BRP;
- adapt the iBRoad concept to become part of EPCs;
- test and evaluate the applicability of iBRoad2EPC in six countries (Bulgaria, Greece, Poland, Portugal, Romania and Spain), including training for issuers and EPC issuers;
- facilitate the adoption and exploitation of the iBRoad2EPC model across Europe.

The iBRoad2EPC energy consultancy tool combines the key elements of a BRP – a targeted roadmap for long-term renovation that avoids lock-in effects.

The iBRoad2EPC is a consultation tool provided by qualified professionals for building owners. It offers an initial plan for renovating a building to achieve long-term climate neutrality. The plan may involve a single, complete renovation or a phased approach over several steps. Each step is designed to build upon the previous ones, allowing for early preparation of connections between building components and addressing future renovation requirements ahead of time. The iBRoad2EPC is specifically tailored to address building owners' critical questions about the long-term renovation process for their properties.

The online output forms of the iBRoad2EPC basic module provide information about the renovation strategy. The overview page (Figure 12) summarises the renovation strategy. Building components renovated to meet the target standard are displayed in green. If the entire building is green in the target year, it indicates that the building will have met the national climate goals of the respective Member State.



Figure 12- Overview page of the iBRoad2EPC online output form - iBRoad2EPC ('iBRoad2EPC', 2023)

Each renovation step has a dedicated subpage that explains in detail what needs to be renovated, when and how to do it, what to be cautious of, and what to pay attention to (Figure 13).

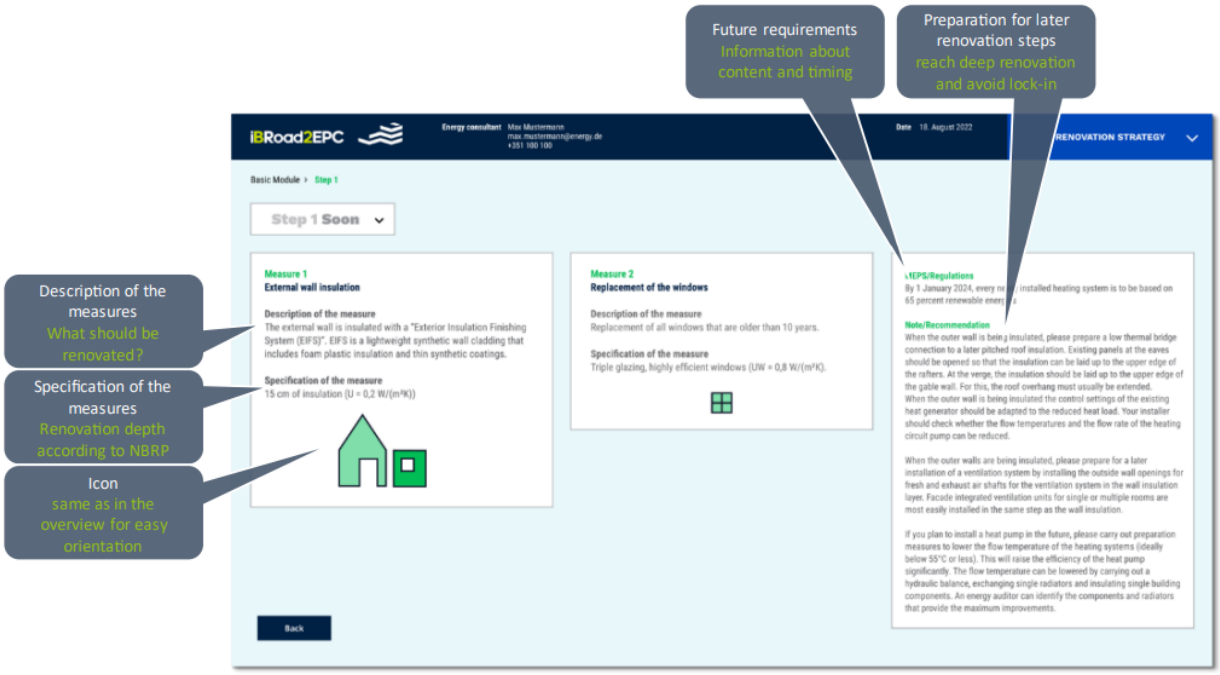


Figure 13- Page 2 of the iBRoad2EPC output form presents detailed information for each renovation step **-** iBRoad2EPC ('iBRoad2EPC', 2023)

Five steps need to be taken to issue a passport according to the iBRoad2EPC (Figure 14).

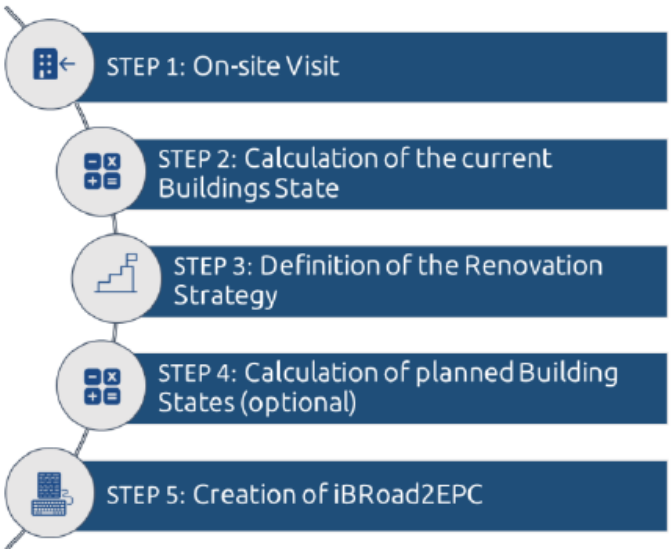


Figure 14- Five steps to issue the iBRoad2EPC - iBRoad2EPC ('iBRoad2EPC', 2023)

Step 1: One-site visits

This first step is important to establish their specific needs regarding the quality of building elements and comfort levels with the owner or occupants. This process helps increase the owners' identification and commitment to the strategy. It also ensures that the long-term renovation strategy is customised to the specific building, considering owner preferences and responding to any questions.

The iBroad2EPC provides a checklist and a blank template to help conduct the visit.

The checklist (Figure 15) assists issuers during on-site visits, helping them gather all necessary information for issuing the iBRoad2EPC. It includes 14 questions focusing on the building owner's views on renovations, the technical state of the building, and any legal requirements. Issuers are advised to use a printable checklist and draft an initial renovation strategy with the building owners during the visit, incorporating their ideas directly.

The provided blank template (Figure 16) details the building's construction year, past improvements, and planned renovations. It includes columns for timelines tailored to each Member State, including future obligations. This template aids in organising renovation plans according to the checklist.

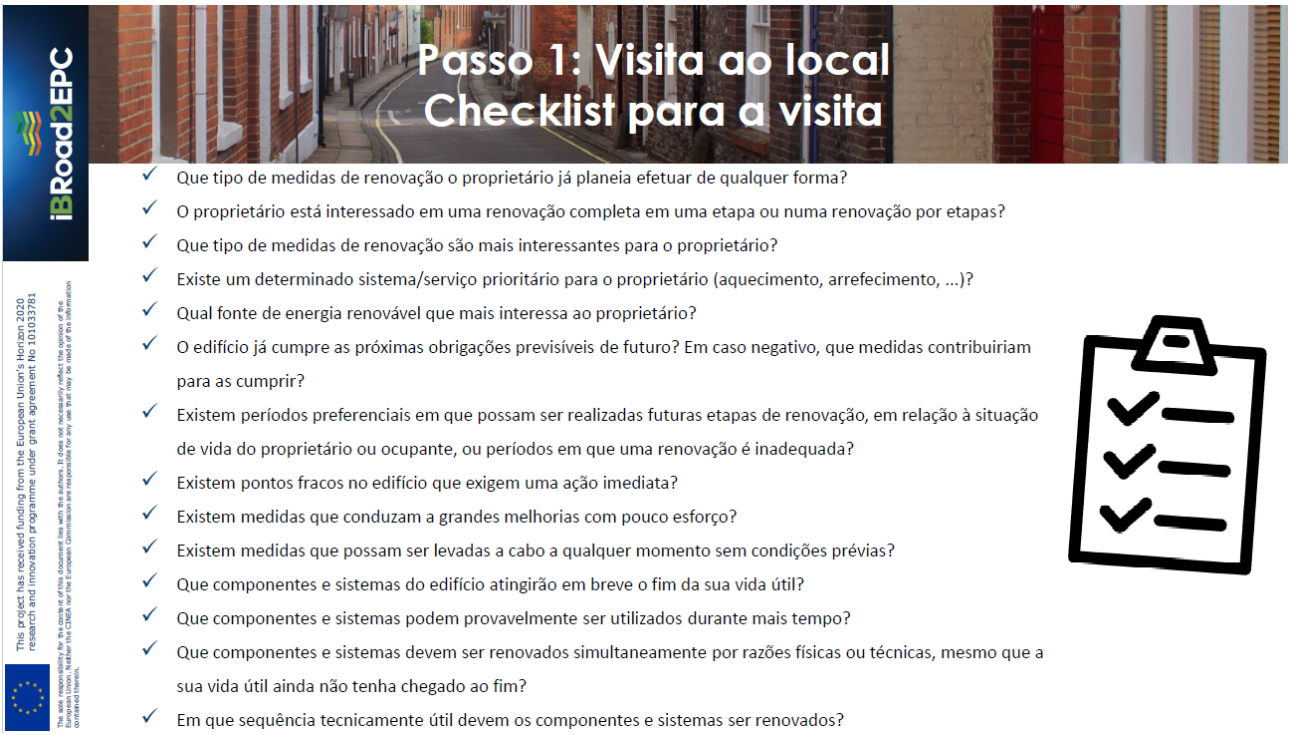


Figure 15- Checklist iBRoad2EPC- Document provided by ADENE

iBRoad2EPC	Ano de construção / instalação	Medidas de melhoria / Renovações já implementadas	O mais depressa possível	Etapa 2 2030	Etapa 3 2040	Etapa 4 2050
Edifício no geral						
Ocupantes						
Cobertura						
Parede exterior						
Janela / Porta						
Pavimento						
Aquecimento						
Água Quente Doméstica (AQS)						
Ventilação						
Arrefecimento						
Casa inteligente						
Iluminação						

Figure 16- Blank template iBRoad2EPC – Document Provided by ADENE

Step 2: Calculation of the current building state

The EPC software determines the building's current state. The calculation process is identical to that used to generate an EPC based on energy demand. This means that an EPC is always issued alongside each iBRoad2EPC, or the iBRoad2EPC can be issued when an EPC is already in place and valid for a building.

Step 3: Definition of the renovation strategy

The central step in the iBRoad2EPC process involves issuers crafting a tailored renovation strategy for a building. This is based on an on-site evaluation, the desires of the building owners, technical insights, and prior experience, intentionally avoiding automation. The strategy focuses on determining the timing and specifics of renovations needed to align the building with the national climate targets, considering all energy-relevant aspects of the structure.

For this task, an issuer can take into consideration the guiding principles to define the strategy:

- One-step renovation or stepwise renovation;

- Age of the components;
- Sequence of measures;
- Components that should be combined;
- Obligations that must be met.

Step 4: Calculation of the planned Building States (optional)

Each country determines whether to calculate energy performance for each renovation stage when implementing step-by-step renovation plans. This process typically involves using energy performance calculation software to model the impact of each step. The building's current energy performance data is initially saved under a new name to represent the baseline scenario. The first step's renovation measures are then applied, and the updated energy performance is calculated. A new calculation version is saved for subsequent steps, incorporating the measures from previous steps and the next set of renovations. This iterative approach continues until all steps are completed, gradually achieving the desired energy performance target.

There is also the IEQ module in iBRoad2EPC, which allows issuers to evaluate a building's indoor environmental quality (IEQ), focusing on four key factors: indoor air quality, thermal comfort, lighting, and acoustics. Developed as part of the X-tendo project (X-Tendo Toolbox, n.d.), an IEQ comfort indicator and the Comfort Asset Rating Procedure (CARP) were introduced to assess and rate these aspects systematically. iBRoad2EPC incorporates CARP, enabling collecting the necessary data through checklists for a comprehensive comfort evaluation. This module was used to assess the comfort levels of the households in this study by filling in the spreadsheet on the passport platform with data related to indoor air quality, thermal comfort, lighting, and acoustics.

Step 5: Creation of iBRoad2EPC

Using the iBRoad2EPC Assistant tool, a BRP will be created (Figure 17).

This tool offers an online format with a clear design to assist issuers with prefabricated content. It also helps issuers assign renovation measures at a specific point and easily overwrite default texts.

The iBRoad2EPC Assistant allows user-friendly input of building information, supported by dropdown menus (Figure 18), prefabricated text fields, and functionalities.

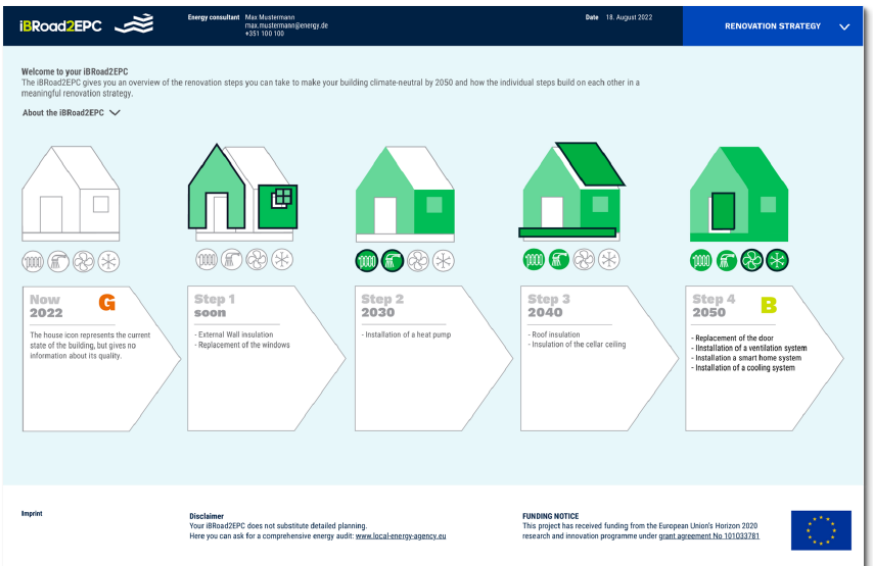


Figure 17- Preview of the iBRoad2EPC: overview page for building owners ('iBRoad2EPC', 2023)

There is a well-established link between energy poverty, precarious housing conditions, and unmet energy needs. Households experiencing energy poverty are often forced to live in poorly performing buildings, leading to increased vulnerability to extreme weather, health issues, and high energy costs. Energy poverty affects millions of households, particularly those living in poorly performing buildings, exacerbating social inequalities and hindering climate goals. These homes fail to meet the basic needs of thermal comfort and health and contribute disproportionately to energy consumption and greenhouse gas emissions. Addressing these challenges requires significant energy efficiency upgrades, mainly through deep renovations, which are pivotal in tackling energy poverty and improving living conditions.

Deep renovation, particularly in stages, offers a practical and scalable approach to improving building energy efficiency. When carried out in a structured and planned manner, this method ensures compatibility between successive renovation steps and the final energy performance goals. However, a significant research gap remains in understanding how tools like the BRP can be integrated into this process to support the rehabilitation of low-energy-efficiency homes, particularly in contexts of energy poverty. The BRP offers potential as a tool to define and prioritise renovation measures, aligning them with the needs and constraints of vulnerable households.

The relevance of addressing energy poverty through energy-efficient building renovations lies in its environmental, economic, and social benefits.



Figure 18- iBRoad2EPC Assistant: The overview includes all renovation steps and the measures contained in each step, regulation targets and project details. iBRoad2EPC Platform provided by ADENE

From an environmental perspective, improving the energy efficiency of the worst-performing buildings is critical for reducing CO_2 emissions and achieving climate goals. Targeting these buildings not only helps mitigate environmental impacts but also contributes to the broader sustainability of the built environment. Economically, energy-efficient renovations directly reduce energy costs, particularly for vulnerable families. By lowering energy consumption, these measures alleviate financial stress on low-income households, breaking the cycle of energy poverty and enhancing economic resilience.

Socially, renovating poorly performing buildings improves thermal comfort, well-being, and health for occupants, addressing the critical needs of those living in inadequate housing. Furthermore, these efforts are vital in promoting equity by ensuring the energy transition is fair and inclusive, leaving no one behind.

Despite these clear benefits, significant research gaps remain. Integrating tools such as the BRP in contexts of energy poverty is not yet fully understood.

Key questions include how the BRP can effectively prioritise renovation measures for homes with limited resources and how its implementation can be adapted to the specific needs of vulnerable communities. Additionally, there is a need to explore the policy frameworks and financial mechanisms required to support the adoption of BRPs in contexts of energy poverty. Overcoming technical and financial barriers to staged deep renovations is essential to ensure these solutions are accessible and feasible for low-income households. Addressing these gaps will be crucial to developing effective strategies for combating energy poverty while fostering sustainable and equitable urban development.

This research is driven by the need to understand how integrating tools like the BRP can prioritise and optimise renovation efforts in the context of energy poverty. It also seeks to explore how such measures can contribute to environmental sustainability by reducing CO_2 emissions and social equity by enhancing the well-being of occupants and ensuring a just energy transition. The study aims to provide actionable solutions that align with broader climate, economic, and social objectives by filling these knowledge gaps.

3. METHODOLOGY

A comprehensive methodology focusing on a case study approach was used to achieve the research goals. First, a preliminary analysis of the building's current state was conducted, which involved on-site visits and tenant surveys. Additionally, individual context was assessed to gain a complete understanding of the scope of energy poverty. The methodology used for this dissertation is summarised in Figure 19.

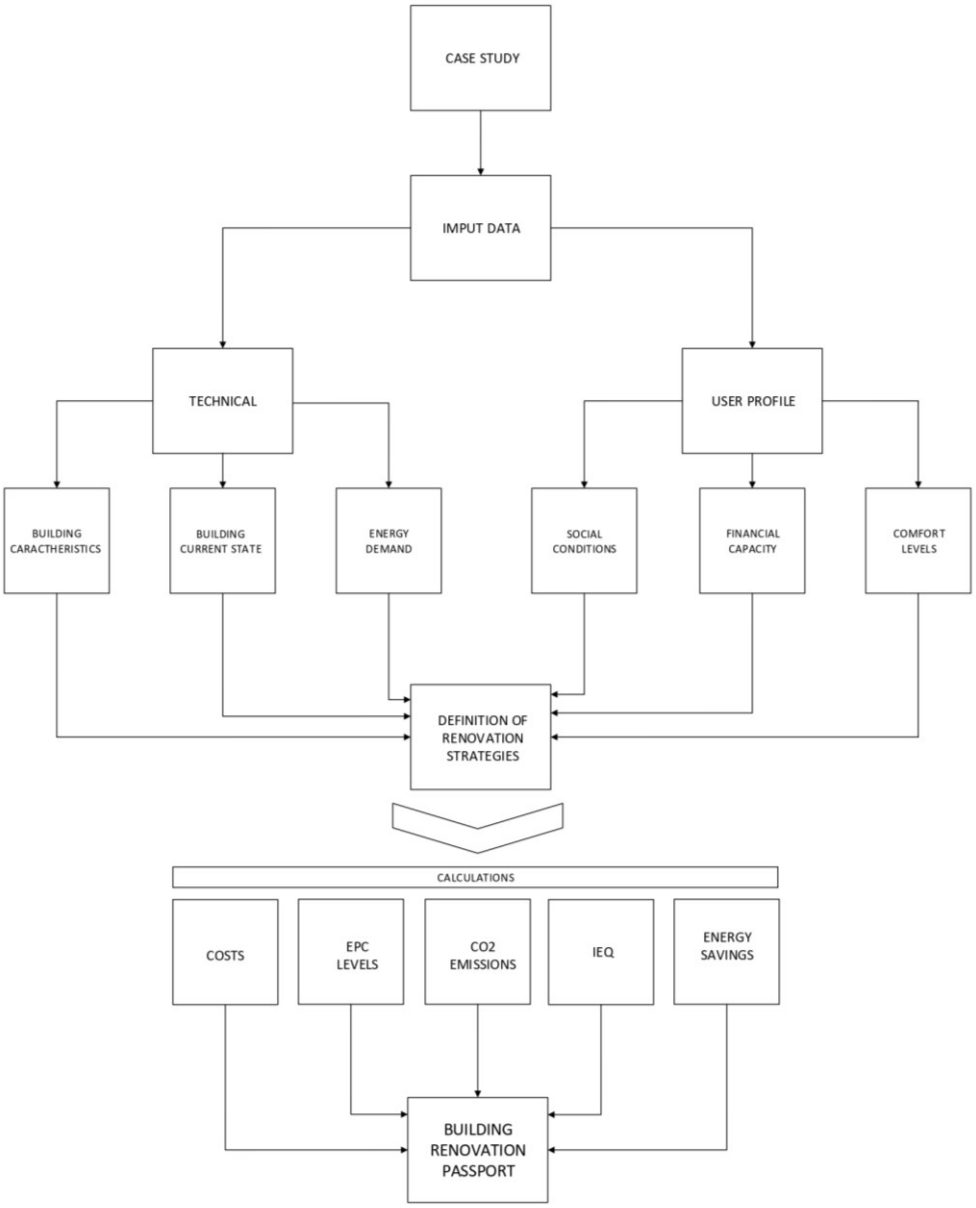


Figure 19- Dissertation flowchart

Simulations were conducted to explore various scenarios, offering insights into proposed rehabilitation interventions' potential effectiveness and adaptability. Calculations were performed to determine energy demand and to quantify the savings generated by each renovation measure. Additionally, cost evaluations were carried out to assess the financial feasibility and sustainability of the proposed rehabilitation solutions. Based on prior findings, an individualised plan was developed. This study aims to analyse the potential use of BRPs as an effective tool for renovating low-income housing in Portugal, providing valuable insights into the most effective renovation measures. The following sections provide further details.

3.1 Case Study

The methodology was applied in a case study representative of the Porto building stock, mainly regarding the construction period and materials. This case study is situated in Porto, in the North of Portugal, and four households belonging to a cluster of houses known as "Islands," an important part of the city's history, were analysed. The "Islands" were created due to the city's inability to cope with the growing demand for housing. This residential typology, created long before the industrialisation period, was greatly enhanced by the industrial development of the 1800s. In 1885, a survey reported approximately 530 islands in Porto, which provided housing for around 20,000 inhabitants (Vasquez, 2015). The rows of small, single-storey houses were built behind the bourgeois housing plots in Porto. These houses typically had very small areas, with only one door and one window on a 4-meter front façade. Most of them were precariously built, without adequate infrastructure, and often centres of insalubrity and disease; therefore, these families are usually in a situation of energy poverty. The case study is a clear example of this typology (Vasquez, 2015).

The selected four attached single-family houses (n° 1, 3, 5 and 13) belong to a group of thirteen (Figure 20). Seven houses are currently vacant and in varying states of disrepair. Nevertheless, they were built before any thermal regulations. The construction comprises granite walls with several modifications but is generally characterised by low construction quality and poor energy performance.

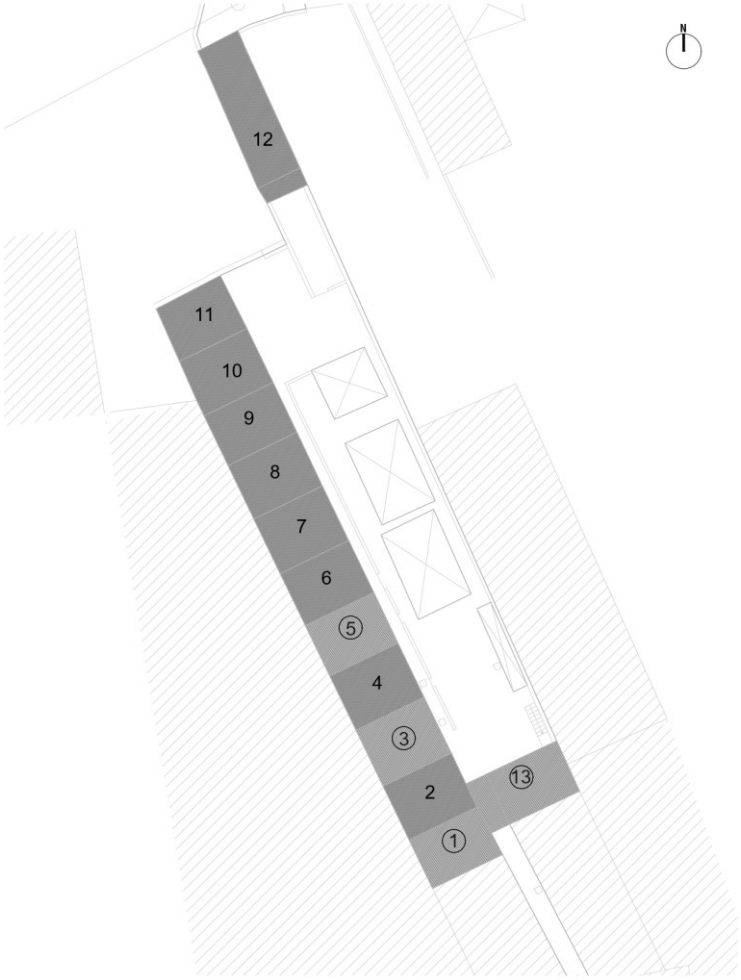


Figure 20 - Site plan for the case study houses (Houses n° 1, 3, 5 and 13)

Official records show that these houses were registered in 1967, corresponding to 27.1% of the number of buildings by the year of construction (Figure 21).

Of the total conventional dwellings for habitual residence, 70% were owner-occupied, the remaining were rented or in other situations (30%), and individuals or private companies owned 71%. This case study is part of the 30% of rented houses owned by a private owner (Figure 22).

These buildings do not have built-in heating and cooling systems to maintain comfortable indoor temperatures throughout the year. Instead, they rely on natural ventilation, and the residents often use portable electric radiators for heating. These radiators are typically energy inefficient and may not evenly distribute comfortable temperatures. Additionally, there is no equipment for cooling the buildings.

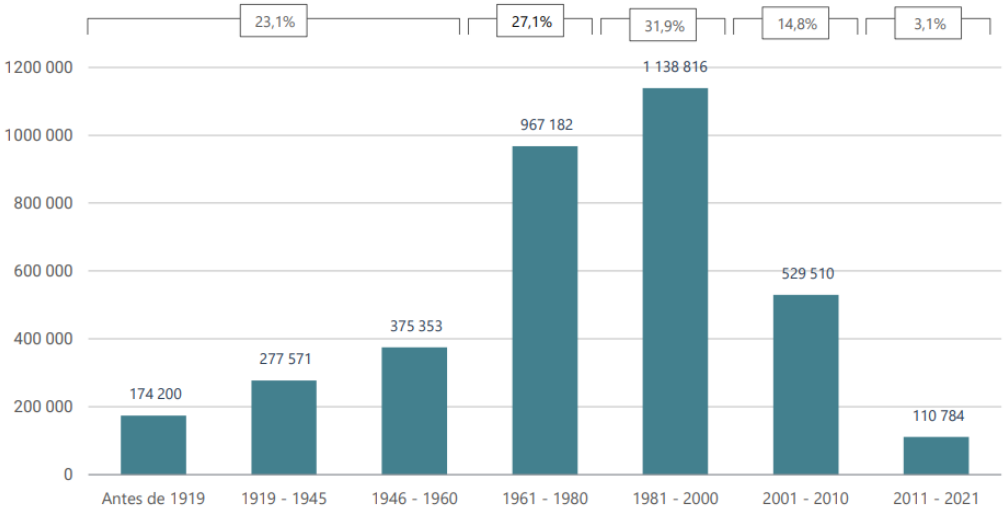


Figure 21- Number of classic buildings by construction period, 2021

INE, Recenseamentos da População e da Habitação- (INE, 2024)

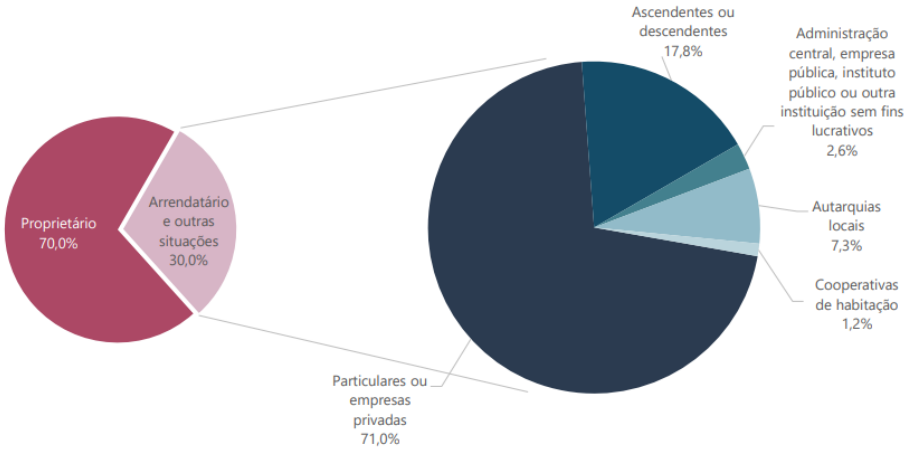


Figure 22- Proportion of conventional dwellings occupied as a usual residence by the owner, 2021 INE, Recenseamentos da População e da Habitação- (INE, 2024)

3.2 On-site Visits

On-site-visits provide the opportunity to directly engage with vulnerable households, tenants and landlords, whom some researchers consider as hard-to-reach energy users (HTR) (Mundaca et al., 2023; Sequeira et al., 2024) who may have barriers to understanding or accessing energy efficiency improvements. HTR energy users encompass individuals who are physically difficult to reach, underserved, or challenging to engage and motivate in demand-side energy programmes (Mundaca et al., 2023). These users often include low-income

families, elderly residents, single parents, or those with low digital literacy. Face-to-face interaction can bridge communication gaps that may be present in digital or remote outreach strategies.

Existing research finds that significant population groups are not reached with traditional one-size-fits-all policies and interventions (Ring et al., 2022). Tailored energy efficiency advice can conduct an in-depth assessment of a building's energy performance and provide personalised advice on energy-saving measures. This approach can be more effective for people who may not respond to general energy efficiency advice and prefer practical, tangible solutions specific to their living conditions.

A one-site visit can create a sense of ownership and empowerment by actively involving occupants during the visit and demonstrating energy-saving opportunities. People are more likely to embrace the proposed solutions when they find them relevant and applicable to their daily lives and feel included in decision-making.

In addition to gauging the conditions of these houses, several site visits were conducted using the iBRoad2EPC checklist and blank template (Figures 15 and 16). This approach aimed to identify the tenants' renovation preferences across different stages: ASAP, 2030, 2040, and 2050. The goal was to begin outlining a strategic renovation plan tailored to their needs. Besides the tenants' preferences, the landlord's point of view was also considered when shaping the renovation strategy.

3.3 User Profile

In the Portuguese context, energy poverty results from low incomes, difficulty accessing efficient and quality energy services, and low home energy performance. In the national context, it is common for citizens to adopt practices to reduce their energy costs by restricting their energy use. This often results in lower comfort and well-being for families who lack the disposable income to access more efficient energy services or implement measures to increase the thermal comfort of their homes. Impacting social well-being, quality of life, health, and labour productivity for all families, not just those facing economic hardship (ELPPE, 2024).

To evaluate the social conditions of the occupants in the case study, a survey was conducted in conjunction with an on-site visit and an observation of the buildings' physical conditions. This approach aimed to determine whether these dwellings align with the indicators established in the ELPPE and ICOR, as discussed in the previous section.

This study examined four ELPPE indicators chosen for their accessibility and consideration of occupant sensitivities: households that are unable to keep their homes adequately warm, dwellings with issues such as infiltration, humidity, or rot, and homes that remain uncomfortably cool during the summer.

The ICOR indicators were employed to evaluate structural problems and building pathologies, focusing on key aspects such as dwellings with leaking roofs, damp walls, floors, or foundations, or rot in window frames or floors; the absence of a bath, shower, or toilet inside the accommodation; insufficient natural light on a sunny day; and the proportion of residential buildings with an energy efficiency class of C or lower.

3.4 Technical Data

Various factors were considered to estimate the energy demand of the houses, including the current state of the building based on its construction characteristics, such as location, domestic hot water types of equipment, ventilation, occupancy, and local weather conditions. The collected data was input into the calculation file to determine the energy certification level.

The building's condition was evaluated using EPC software, following the methodology outlined in the SCE Manual, which implements Portuguese Decree-Law 101-D/2020 of December 7. The SCE Manual specifies the calculation methodology for assessing the energy performance of buildings within the scope of the energy certification system. This evaluation results in the assignment of an energy class, determined by comparing the primary energy consumption for regulated uses, including the contribution from renewable energy sources, between the actual and reference buildings. This is an annual primary energy indicator for useful indoor floor area units. Energy needs are calculated under standardised conditions to ensure indoor air quality, thermal comfort, and health requirements for indoor spaces (SCE Manual).

The methodology for determining the EPC is based on the following:

- The assessment of buildings' energy performance is an analysis based on the calculation of energy consumption, which reflects typical energy consumption for space heating and cooling, space ventilation, hot water production, and other technical building systems, which is expressed by a numerical indicator of primary energy use in kWh/(m^2.year);
- The energy performance of buildings is assessed, considering the energy needs of certain uses, such as space heating and cooling, ventilation and domestic hot water. These are determined to directly or indirectly optimise building occupants' health, thermal comfort, and indoor air quality;
- The building's energy performance is expressed through a numerical indicator representing the primary energy required to meet the energy needs referred to in the previous paragraph. This indicator considers the energy from renewable sources supplied to the building and generated and used in the building.

3.5 Definition of the Renovation Strategies

The renovation strategy aims to identify opportunities to improve energy efficiency, increase thermal comfort, and improve the quality of the spaces' interior environments. This has to be done through refurbishment or renovation construction solutions and replacing equipment with more efficient models, following ELPPE guidelines. When developing a long-term renovation strategy for an individual building, two fundamental questions must be addressed: when to renovate and what specific interventions to implement. A comprehensive evaluation is required to answer these questions, considering various factors influencing the renovation's timing and scope.

The building's characteristics provide crucial insights for conducting a comprehensive assessment of which interventions should be prioritised and which issues require immediate attention. Factors such as the type of construction, the building's age, existing anomalies, and the condition of its components are key to determining the necessary measures and those elements that can continue to function effectively for years to come. Additionally, it is important to consider the building's EPC rating, its overall energy demand and the climate zone in which it is located, as these are critical factors in shaping the scope and urgency of the proposed energy efficiency measures.

The prioritisation of renovation measures must also consider the societal impact on the occupants, including their specific needs and comfort levels. This ensures that the proposed improvements enhance the building's performance and the quality of life for its residents.

Renovation measures should be strategically sequenced to maximise efficiency and cost-effectiveness. For instance, improving the building envelope in advance allows for installing a more efficient and economical heat generator with lower capacity.

Beyond considering the age of individual components, assessing which elements should ideally be renovated together is essential. For example, simultaneously addressing window installations and façade renovations can prevent connection-related issues and ensure a more integrated and durable solution.

Renovation measures must be strategically planned to ensure compliance with the obligations outlined in the EPBD 2024 recast, with which buildings must align. This dissertation used a target of 60% energy savings—previously defined as deep renovation—as a benchmark. Additionally, intermediate targets of 16% energy savings by 2030 and 20-22% by 2035 were adopted. The national renovation strategies will determine the remaining goals. However, for this dissertation, the renovation strategy aims to achieve the highest possible EPC rating by 2050 if technically feasible.

Various scenarios were developed to evaluate potential outcomes by considering a range of critical parameters, including financial costs, CO_2 emissions, energy demand, EPC levels, and technical feasibility. These scenarios were designed to provide a comprehensive understanding of the trade-offs and benefits associated with different renovation strategies. Importantly, the scenarios also took into account the specific needs and preferences of both tenants and landlord, ensuring that the proposed solutions were not only technically and environmentally viable but also socially acceptable and aligned with the stakeholders' priorities. This holistic approach aimed to balance energy efficiency goals with practical considerations and stakeholder expectations.

1. The iBRoad2EPC renovation scenario outlines four steps according to a timeline extending to 2050.
    a. ASAP (as soon as possible): focuses on addressing the most urgent renovation measures. This includes tackling structural pathologies and damages from a construction perspective and meeting the immediate needs of the occupants;
    b. 2030: This step prioritises equipping the building with an energy-efficient envelope and an effective ventilation system, improving insulation, reducing energy losses, and ensuring better indoor air quality;
    c. 2040: This renovation step focuses on completing the building envelope improvements and installing heating equipment to enhance energy efficiency and occupant comfort;
    d. 2050: The final step addresses renovating the domestic hot water system. This step, involving the most significant investment, is planned for the final stage, anticipating technological advancements that will make more efficient and cost-effective devices available.
2. Landlord: includes the renovation measures the landlord has planned based on their investment estimations. This scenario serves as a benchmark for comparison with other proposed renovation pathways.
3. The Envelope Measures with Ventilation System Scenario focuses on implementing passive renovation measures, including self-adjustable grills and a ventilation system in the bathroom. This scenario evaluates whether passive solutions alone can achieve decarbonisation goals while assessing their impact on energy demand and associated costs.
4. The Envelope Measures with a Ventilation System scenario incorporates mechanical ventilation with heat recovery (MVHR). This approach anticipates future climate change and the projected increase in global temperatures, exploring the possibility that a heating system may no longer be necessary. In-

stead, the MVHR system alone could provide sufficient thermal comfort while maintaining energy efficiency.

After defining the renovation scenarios, the next step is to calculate each scenario's energy performance, costs, and environmental impact to enable a comprehensive comparison. The results of this analysis are presented in the following section.

3.6 Calculations for Renovation Scenarios

The current condition of the buildings will be compared with the proposed energy renovation scenarios. Using the official simulation software that supports the implementation of SCE - ITECONS software (*ITECONS*, 2024), the energy certification rating for each scenario is determined, allowing for a comparison of the solutions based on energy demand, certification levels, CO_2 emissions, and the percentage reduction in energy demand achieved. IBRoad2EPC recommends this methodology for easy connection to the EPC, which facilitates the implementation of the renovation passport.

The calculation tool enables the completion of all necessary information for issuing Pre-Certificates and Energy Certificates. This tool is designed to automatically verify minimum and energy requirements, whenever applicable, for buildings constructed after July 1, 2021. Additionally, it allows for a technical-economic analysis of improvement measures. The tool is structured to generate the XML file and the Inspection Report required for issuing Energy Certificates.

It is also possible to store descriptions of construction solutions in databases and load them directly into the calculation sheets whenever needed. The tool features more automated functionality, streamlining the overall process.

The calculation begins with the XML sheet from ITECONS, which defines the existing condition of the building. For each renovation scenario, a proposed set of measures is introduced incrementally. The measures taken into consideration for this study were chosen to improve the thermal performance of the building. The criteria for the selected measures were the best energy performance, the cost and the most commonly used practices in the construction sector in Portugal.

These measures include enhancements to the building envelope, such as insulating exterior walls to improve the thermal coefficient, insulating the roof, and completing the proper insulation of the opaque envelope. Glazed elements are replaced with energy-efficient solutions to address the building's energy inefficiencies.

The ventilation system has also been improved to mitigate significant pathologies in these homes, such as mould. Finally, domestic hot water production and space heating equipment are introduced, prioritising systems powered by renewable energy sources. Each scenario is evaluated as a whole, producing a final result for comparison.

In addition, the investment cost of each scenario is calculated using Cype's Price Generator tool (Gerador de Preços para Construção Civil, Portugal, CYPE Ingenieros, S.A., 2024), providing a detailed analysis of the financial requirements for each renovation strategy. The estimated investment for each set of measures is calculated to enable a comparison of results across scenarios.

Finally, a renovation strategy is selected and introduced into the iBRoad2EPC platform, aligning with the chosen approach to achieve the desired energy efficiency and sustainability goals.

3.7 Creation of the Building Renovation Passport

After determining the renovation pathway that best aligns with the EU's decarbonisation goals while considering the specific needs of socially vulnerable households living in low-efficiency homes, the next step is to finalise the input into the iBRoad2EPC platform, creating a passport for each household.

The iBRoad Assistant served as a platform for issuers to log in and initiate the process for a specific building, enabling the creation of distinct projects with one iBroad2EPC per building. The first step involves entering key building information, such as the climate zone, year of construction, and building type. Issuers must also input details regarding tenure status and renovation triggers and upload the EPC Certificate.

The next step involves inputting the developed renovation strategy. The renovation phases are organised into predefined time frames: Step 1 (ASAP—As Soon As Possible), Step 2 (2030), Step 3 (2040), and Step 4 (2050). For each phase, renovation measures are introduced via a drop-down menu, allowing issuers to select the appropriate types of measures from a predefined list.

The iBRoad2EPC Assistant provides ready-made descriptions for each renovation measure. Technical specifications are automatically generated in accordance with the specific requirements of the implementing country and, where applicable, adjusted based on the climate zone, building type, and tenure status. These descriptions outline the quality of each measure in alignment with the respective country's long-term targets.

The objective is for the building to achieve climate neutrality by the final renovation stage, as stipulated in national climate protection targets. To meet this goal, all building components that do not meet the required

standards for climate neutrality in their current state must be addressed as renovation measures within one of the defined renovation phases.

Once all renovation measures have been entered, the iBRoad2EPC Assistant automatically generates preparatory recommendations to prevent lock-in situations. These recommendations are displayed at the end of each renovation phase in the overview unless no applicable recommendations exist for that particular step (Figure 23).

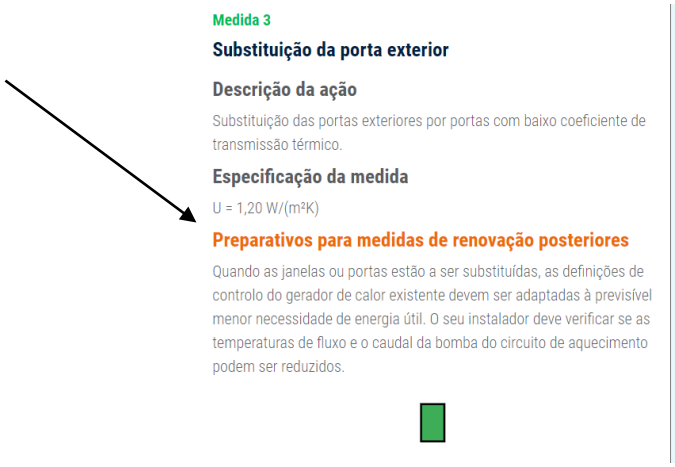


Figure 23- Recommendation for the next step iBRoad2EPC- House n° 4- iBRoad2EPC Platform provided by ADENE

After all renovation measures envisioned by the issuer have been assigned to the respective renovation phases and the corresponding recommendations have been generated, the basic iBRoad2EPC process is completed. Issuers can then exit the editing mode by selecting the 'Create the overview document' button (Figure 24).

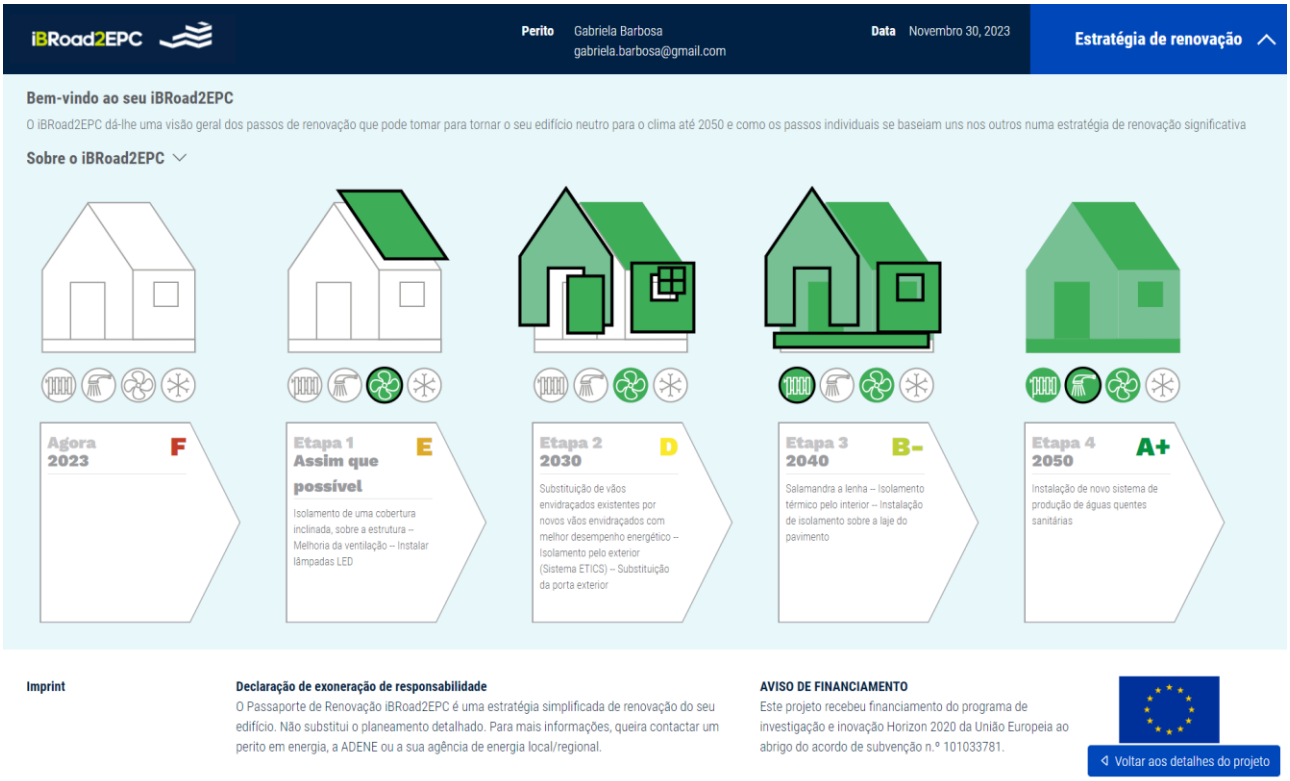


Figure 24 Overview of the iBRoad2EPC document BRP of House n° 3- iBRoad2EPC Platform provided by ADENE

This methodology is straightforward, as it builds upon the already established framework of EPC) issuers while incorporating tailored improvements specific to each household. The BRP is designed to serve as an EPC extension, offering a more comprehensive and personalised approach. The iBRoad2EPC platform is built for simplicity and accessibility, positioning itself as a bridge between the existing EPC framework and future BRPs. These BRPs take a step further by providing a tailored, step-by-step renovation roadmap over time.

The following sections present a detailed characterisation of the case study, and an evaluation of the results obtained from this analysis.

4 CASE STUDY CHARACTERISATION

This section outlines the case study that implemented the previously proposed methodology to achieve the study's objectives. The selection of the four houses was predicated on the occupants' willingness to collaborate in this study. These houses serve as representative examples of a constructive and typical architectural typology. They are located in northern Portugal, in Porto, less than 5 km from the sea, at an altitude of 72 m above sea level (Figure 25).

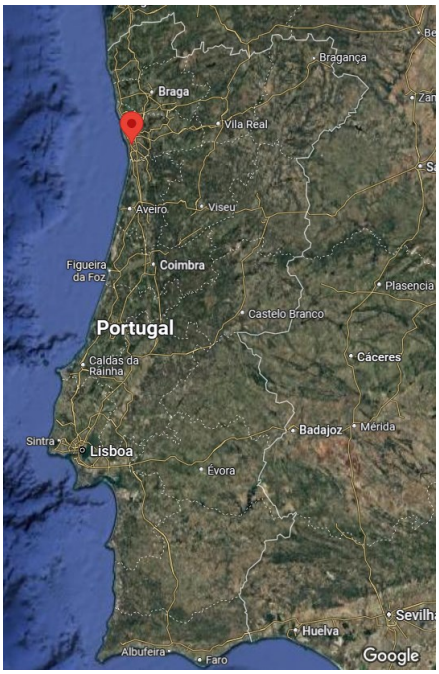


Figure 25- Location of the case study- Google Maps

This study used climate data to evaluate the building's thermal behaviour and energy performance. Porto experiences mild and moderate weather conditions, with significantly more winter rainfall than summer. According to the Köppen-Geiger climate classification, Porto has a Csb climate type, with an average annual temperature of 15.1°C and annual rainfall of 1,285 mm (Clima Porto, 2024).

Portuguese Decree-Law No. 118/2013 of August 20 specified that Porto is classified as NUTS III—Grande Porto within Portugal's zoning framework. Three winter climate zones (I1, I2, and I3) and three summer climate zones (V1, V2, and V3) are defined for thermal quality requirements. Winter zones are determined by the number of degree days (GD) at 18°C during the heating season, while summer zones are based on the average outdoor temperature ($\theta ext,v$) during the cooling season.

According to this classification, the case study falls under winter zone I1 and summer zone V2, as illustrated in Figure 26.

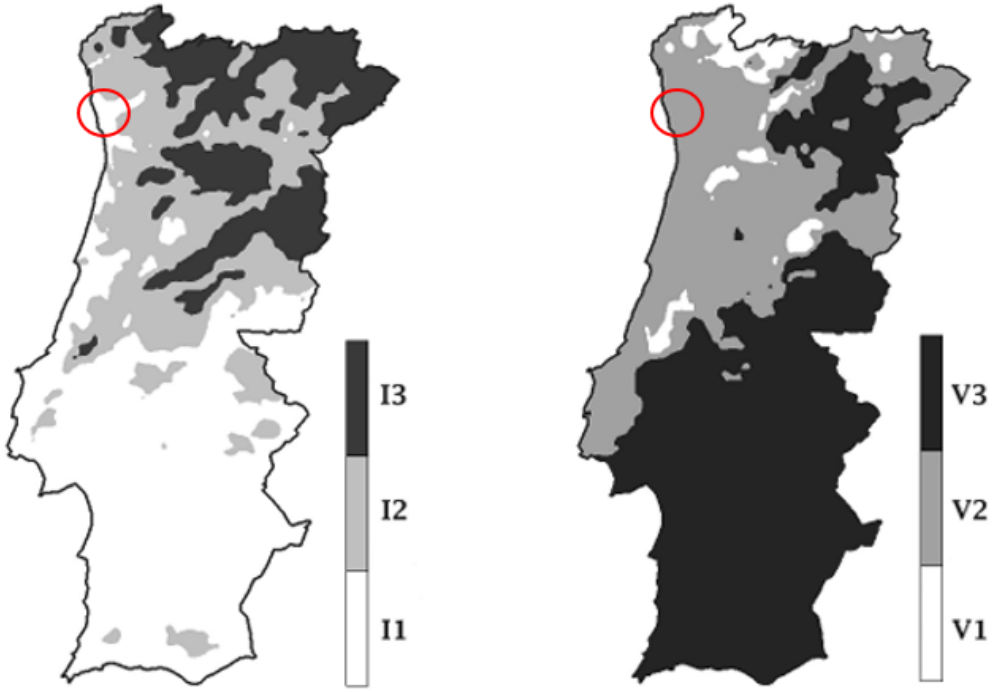


Figure 26- Portugal's climate zones in Winter and Summer- Dispatch (extract) n. ° 15793-F/2013

The typology of these households is defined by terraced single-family homes, each consisting of a ground floor and an upper level that includes a mezzanine, occupying approximately half of the building's footprint. House No. 13 is the only structure with a single upper floor above the ground level. In these homes, the bathroom is typically outside the interior, except for House No. 3, which features an internal bathroom. Figures 27, 28, and 29 present the different floor plans of the studied houses.

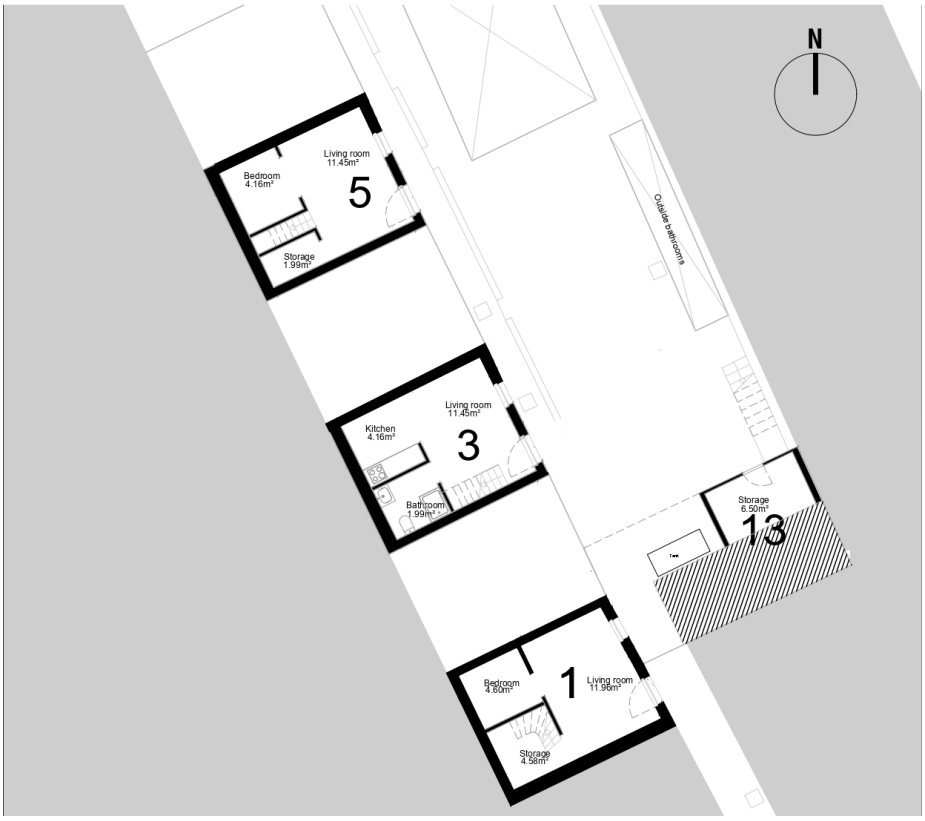


Figure 27- Ground floor plan – Houses n° 1, 3, 5 and 13

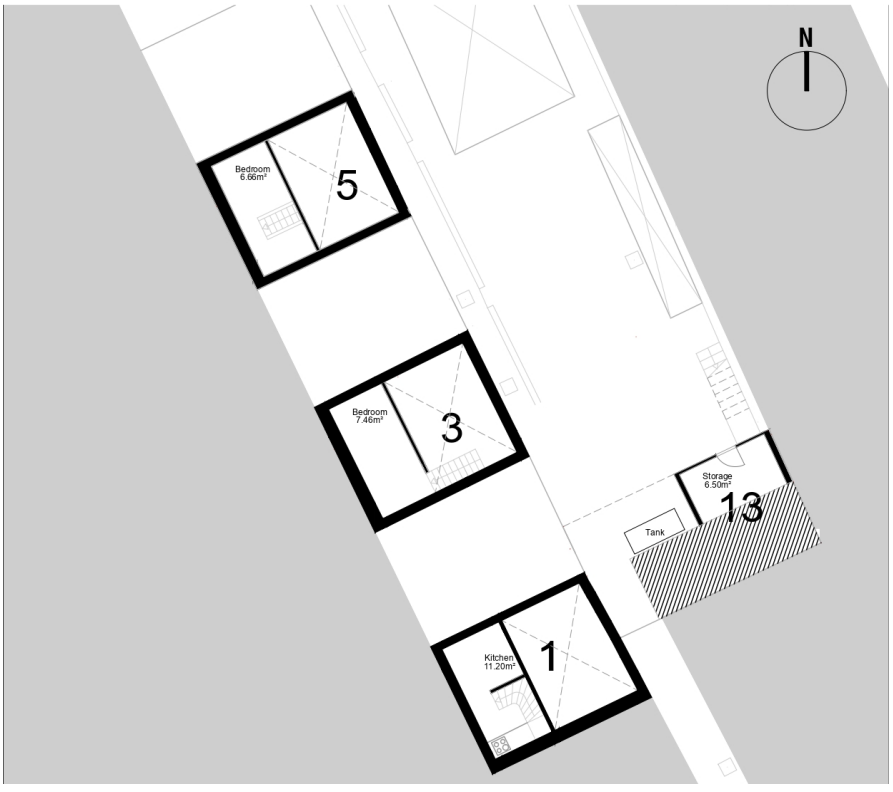


Figure 28 – First-floor plan – Houses n° 1, 3, 5 and 13

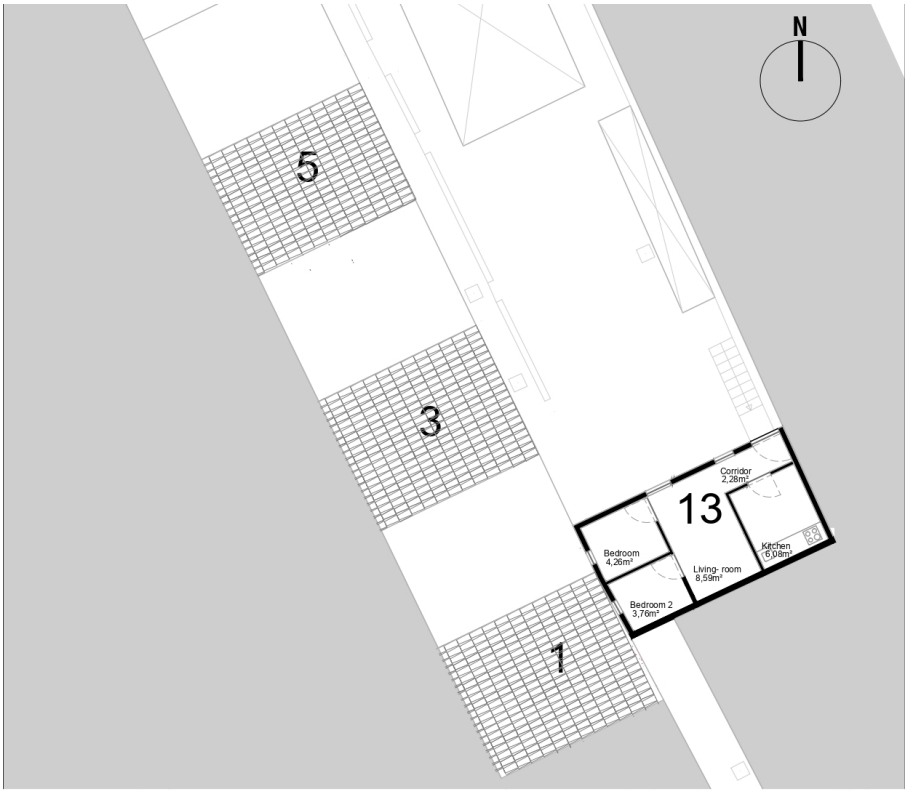


Figure 29 - Second-floor plan – Houses nº 1, 3, 5 and 13

The summary for each household offers a comprehensive overview of the specific characteristics of the building, including its structural and energy performance details, as well as demographic information about the occupants, such as their age and gender. Additionally, it highlights the most pressing needs of the residents, taking into account both the physical conditions of the building and the social and economic challenges faced by the household. This holistic approach ensures that the analysis is tailored to address each household's unique circumstances and priorities.

House No. 1 (Figure 30) is a one-bedroom dwelling with a floor area of 28.96m² and a main façade oriented to the northeast. The house does not have a bathroom inside. The building lacks heating or cooling systems, and an electric water heater provides domestic hot water (DHW). Ventilation occurs naturally through the window frames and kitchen exhaust. The northeast-facing exterior wall consists of 30 cm thick granite masonry, single-glazed sash windows framed in wood, no shutters, and a wood door. The interior walls, adjacent to neighbouring buildings, are made of plastered granite with an approximate thickness of 30 cm. The floor slab is in direct contact with the ground and is finished with vinyl flooring. The roof is sloped, lacks thermal insulation, and includes a single-glazed skylight without sun protection framed in iron. There is visible mould on the walls, and the windows are inoperable.

The occupant, a male aged 44 and currently employed, expresses primary concern regarding the inoperable windows. He also highlights issues related to inadequate ventilation and the associated mould growth. Additionally, he notes the cold temperatures experienced during the winter months, although he mentions that the house remains relatively cool during summer. The occupant does not possess a portable heating system. He didn´t want to give his opinion about the house's refurbishment.



Figure 30- Houses n° 1(left) and House n° 3 (right)

House No. 3 (Figure 30) is a one-bedroom dwelling with a floor area of 28.96m², featuring a main façade oriented to the northeast. The building lacks heating and cooling systems, with domestic hot water (DHW) supplied by an electric water heater. Ventilation is natural, achieved through the window frames and exhausts in the sanitary facilities and kitchen. The distribution of glazed openings facilitates night-time cooling. The exterior wall, facing northeast, consists of 30 cm thick granite masonry, single-glazed sliding windows with aluminium frames, and roller shutters. The remaining walls, shared with adjacent buildings, are composed of exposed granite with an estimated thickness of 30 cm. The floor slab is in direct contact with the ground and covered with ceramic tiles. The roof is sloped, lacking thermal insulation, and features a double-glazed skylight without sun protection, supported by wooden frames.

Two occupants, over 60 years old (one retired, one employed), reside in this dwelling. They rely on a portable heating system and prioritise resolving winter heating issues, citing the ongoing concerns of dampness and mould on the walls and ceilings. While they have no specific preferences regarding equipment installation, they desire to retain the visible granite on the walls in the living room. Additionally, they prefer the renovation work to be completed in a single phase.

House No. 5 (figure 31) is a two-bedroom dwelling with a floor area of 25.33m² and a main façade oriented to the northeast. The house does not have an internal bathroom or kitchen. It lacks heating and cooling systems, with domestic hot water (DHW) supplied by an electric water heater. Ventilation occurs naturally through the window frames, and the configuration of the glazed openings allows for night-time cooling. The exterior northeast-facing wall comprises 30 cm thick granite masonry featuring a single-glazed casement window framed in wood with roller shutters and a metallic door. The interior walls, shared with adjacent buildings, are made of plastered granite with an approximate thickness of 30 cm. The floor slab, which is in direct contact with the ground, shows visible signs of deterioration. The sloped roof lacks thermal insulation and includes a single-glazed skylight without sun protection framed in iron. Visible mould is evident on the wall surfaces.

The occupant, a male aged 35 and currently employed, expresses concerns regarding the deteriorating condition of the floor and the visible mould on the walls. He has no opinion on the winter cold, as he recently moved in, and mentions that the past summer was not particularly uncomfortable for him. Additionally, he does not have an opinion regarding the potential refurbishment of the house.

House no. 13 (Figure 31) is a two-bedroom house with a floor area of 24.97m², four façades and openings to the north and west. The toilet is located outside the accommodation. It has no heating or cooling systems. DHW production needs are met with an electric water heater. Ventilation is natural through the window frames and the kitchen extractor fan. Due to their distribution, the glazed windows allow for night-time cooling. The exterior walls have a total thickness of 17cm of uninsulated brickwork, single-glazed windows without sun protection and aluminium opening frames. The exterior pavement has a concrete slab above ground and another above a non-useful space. The roof is sloping with no thermal insulation. Large areas of mould are present on the walls.

The resident of House No. 13 is a 66-year-old woman currently unemployed. She does not have a heating system due to the associated costs. Her primary concerns are the dampness and mould on the walls and ceilings, inadequate heating during winter and cooling in summer. She prefers the renovation work to be carried out in stages and would like sanitary facilities installed inside the house.



Figure 31- House n° 5 (left) and House n° 13 (right)

The foundational elements of this case study's buildings were considered based on typical construction characteristics. The constructive features of existing technical solutions and proposals for energy renovation are critical for a building's thermal performance and occupant comfort, influencing material selection.

For opaque surfaces, thermal transmittance, or U-value, is the key parameter to assess their heat transmission capability under static or dynamic conditions. This data was obtained by considering typical U-values for building envelope elements available in ITE-50 by LNEC. Table 4 presents the main characteristics of the four houses.

Table 4 - Main characteristics of the households (U-value)

Building Elements	Characteristics	U- value (W/m2.ºc)
Exterior walls (Houses n°1,3 and 5)	Granite wall 30cm thick	3,25
Exterior walls (House n° 13)	Brick wall 17cm thick	2,20
Interior walls (between houses)	Granite wall 30cm thick	3,25
Roof (Houses n°1, 3 and 5)	Sloping light roof	3,80
Roof (Houses n°13)	Roof with concrete slab	2,25

It is important to highlight that the houses lack mechanical ventilation systems and rely solely on natural ventilation. This means air circulation depends on openings such as windows and doors, which can be inefficient in maintaining adequate airflow, particularly during adverse weather conditions. Additionally, no equipment is installed for heating or cooling, leaving the occupants vulnerable to temperature extremes in both summer and winter. Domestic hot water is provided through an electric water heater, which, while functional, is not the most energy-efficient option.

These houses are generally characterised by low energy efficiency, which leads to disproportionately high energy consumption even for meeting basic comfort requirements. This scenario highlights the pressing need to address critical aspects of indoor comfort and environmental quality. Implementing measures such as enhanced insulation, modern HVAC systems, or renewable energy technologies could markedly improve thermal comfort and the overall living conditions in these homes.

In the following section, a detailed analysis will outline the measures expected to yield the most significant improvements for these vulnerable households, effectively and sustainably addressing their specific needs.

5 RESULTS EVALUATION

This section will present the findings from assessing the tenants' social conditions, focusing on key energy poverty indicators, the energy performance of the buildings, and the overall living conditions. The analysis aims to provide a comprehensive understanding of the current situation and its impact on the well-being of the tenants.

Additionally, this section will include the results of various renovation scenarios. These scenarios will be evaluated based on their impact on energy demand, CO_2 emissions, required investment costs, and improvements to indoor environmental quality (IEQ). The discussion will explore how each renovation strategy addresses energy efficiency, mitigates carbon emissions, and enhances the overall comfort and health of the living environment while balancing financial feasibility.

5.1 Current State

The on-site visits provided an opportunity to assess the tenants' social conditions and evaluate the buildings' physical state. Through direct observation of construction conditions, it was possible to identify the presence of indicators commonly used to measure energy poverty in Portugal. This dual approach — combining social assessment with structural analysis — gave a comprehensive understanding of the tenants' living conditions and susceptibility to energy poverty, as presented in Tables 5 and 6.

Table 5- Key indicators for measuring energy poverty in Portugal - ELPPE

EP Indicator	House nº1	House nº3	House nº5	House nº13
Population living in homes unable to keep adequately warm	x	x	x	x
Population living in uncomfortably cool housing during the summer	x	-	-	x
Population living in dwellings with problems of mould, humidity or rotting elements	x	x	x	x
Fraction of residential buildings with energy class C or lower	**F**	**F**	**F**	**F**

Table 6- Population living in accommodation with problems related to sanitary facilities and the quality of physical structures - ICOR

EP Indicator	House nº1	House nº3	House nº5	House nº13
Dwelling with a leaking roof, damp walls, floors, or foundation, or rot in window frames or floors	x	x	x	x
Insufficient natural light on a sunny day	x			
No bath, shower or toilet inside the accommodation	x		x	x
With at least one of the problems	x	x	x	x

The results from these tables indicate that nearly all energy poverty indicators were confirmed in the analysed households.

The characteristics of the buildings, along with the location of the houses, ventilation systems, and domestic hot water (DHW) equipment, were used to calculate the energy needs for heating, cooling, and DHW production, as well as the overall primary energy consumption, which is presented in Table 7, providing an EPC level. Additionally, the assessment offered insights into the associated CO_2 emissions, giving a comprehensive understanding of the environmental impact. The energy demand for each house was determined in accordance with EPC requirements set by Portuguese legislation, ensuring that the calculations conform to national regulatory standards for building energy efficiency. This approach enabled a detailed evaluation of each building's energy performance and its potential for improvement through renovation measures.

Table 7- Existing Energy demand of the houses: EPCs

Parameters	House nº1	House nº3	House nº5	House nº13
Energy needs for heating (kWh/y.m²)	258,69	268,88	308,80	394,47
Energy needs for cooling (kWh/y.m²)	9,25	8,84	10,28	8,62
Energy needs for domestic hot water production (kWh/y)	1189	1 189	1783	1 783
Primary energy (kWhep/y.m²)	802,47	828,59	1021,96	1245,45
CO_2 emissions (t/year)	3,35	3,46	3,21	4,50
EPC level	F	F	F	F

5.2 Renovation Strategy

Several scenarios were developed and analysed to determine the optimal renovation strategy. These scenarios allowed for a comparative evaluation of the outcomes, enabling a clear understanding of the potential benefits and trade-offs associated with each approach. The results were presented to all stakeholders, ensuring the proposed solutions aligned with their needs and priorities. This collaborative approach aimed to identify the

most suitable renovation path, balancing energy efficiency, cost-effectiveness, and improvements to the living environment.

These renovation scenarios were designed to enhance the energy performance of key building features. Best practices were adopted to insulate the building envelope and upgrade equipment for optimal energy efficiency. The scenarios also considered implementing actions aimed at energy rehabilitation and passive thermal comfort improvements, mitigating humidity-related issues and replacing deteriorated structural elements. These measures align with the strategic goals set forth by ELPPE (ELPPE, 2024).

The ELPPE outlines a central action framework to improve housing energy efficiency and promote decarbonised consumption. This framework includes:

- Renovation of the opaque envelope by enhancing insulation of walls, roofs, and floors to minimise heat loss;
- Renovation of glazed elements by upgrading windows and doors for improved thermal and energy performance;
- Replacement of deteriorated elements and reduction of dampness;
- Efficient ventilation systems by implementing systems that ensure adequate air exchange while minimising energy loss.

Additionally, the plan emphasises decarbonising energy consumption by incorporating energy-efficient equipment for heating and domestic hot water (DHW), preferably powered by renewable energy sources.

To ensure that the proposed renovation measures achieve the desired objectives, they must comply with the limit values established by the Portuguese thermal regulation, as outlined in Decree-Law No. 101-D/2020. These regulations specify the maximum permissible thermal transmittance (U-values) and other performance criteria for building components tailored to the specific climatic conditions of the buildings' location. Table 8 summarises the renovation measures implemented and their corresponding energy coefficient values.

Table 8- Renovation measures

RENOVATION MEASURES	
BUILDING ENVELOPE	Thermal insulation- Roof 10cm Rockwool (U - 0.35 W/m².K)
	Thermal insulation- Ext walls 10cm of EPS (U - 0.33 W/m².K)
	Thermal insulation - Int walls 8cm of rock wool + plasterboard (U - 0.42 W/m².K)
	Thermal insulation of the ground floor 4cm XPS
	Replacement of the existing windows for double-glazed aluminium windows (Uwdn - 1.94W/m².°C)
	New wooden door (U - 1.20 W/m².K)
EQUIPMENT	Mechanical extractor in the bathroom and an exhauster in the kitchen
	Replacement of showers for water-efficient shower systems
	Self-adjustable grills + Ventax extractor fan
	Mechanical Heat Recovery System
	Pellet stove
	Electric heating system
	LED lighting installation
	Heat Pump for DHW cop 4,3 1,5kw consumo de 361kwh/ano

These measures will be integrated into the various renovation scenarios, considering the particularities of each house and its occupants.

5.2.1 Landlord´s Renovation Scenario

The Landlord renovation scenario presented is primarily tailored to align with measures the landlord considers viable for their investment. He focuses on cost-effective solutions to address the minimum necessary improvements required to enhance energy efficiency. The landlord is a small property investor with some knowledge of refurbishment but shows no interest in investing more than he considers necessary for a return on his investment.

This renovation scenario establishes a baseline for evaluating and comparing various renovation proposals. It provides insights into the potential outcomes of the landlord's planned investment while serving as a reference point to explore alternative approaches.

The scenario aims to highlight how the landlord's proposed measures align with immediate priorities, such as cost-effectiveness and feasibility, while offering a framework for comparison with other renovation possibilities. These alternative scenarios may incorporate more ambitious strategies aligned with the construction sector's

decarbonisation goals, emphasising enhanced energy efficiency, renewable energy integration, and reduced carbon emissions.

By juxtaposing the baseline scenario with these advanced alternatives, stakeholders can make informed decisions that balance financial considerations with long-term environmental and energy objectives. This approach ensures that all parties know the broader impact and potential benefits of pursuing renovations that contribute to the sector's sustainability targets.

The landlord believes that thermal insulation of the sloping roof and the exterior walls using an ETICS is worth considering. However, insulating the interior walls adjacent to neighbouring buildings, which would require internal installation, is not a viable solution, as it would reduce the house's usable area and cover the exposed granite masonry. Installing a heat pump for domestic hot water (DHW) has also been rejected due to its cost and the required space. Furthermore, the owner opposes air conditioning installation for aesthetic reasons, as the external unit would need to be mounted on the main façade and because he associates air conditioning with respiratory problems. He is considering the installation of photovoltaic panels for electricity generation, but only if state funding is available to cover the costs. Regarding the timeline of interventions, he plans to evaluate each tenant's specific needs before making decisions. Table 9 summarises the renovation measures under consideration by the landlord.

Table 9- Renovation measures considered by the landlord

Landlord´s Renovation Scenario
Thermal insulation- Roof 10cm Rockwool
Thermal insulation- Ext walls 10cm of EPS
Replacement of the existing windows for double-glazed PVC windows
New wooden door
Mechanical extractor in the bathroom and an exhauster in the kitchen
Replacement of showers for water-efficient shower systems
Electric heating system
Electric system for DHW

The aforementioned measures were incorporated into determining each residence's EPC rating, illustrated in Table 10.

Table 10- Results of the energy demand of the Households according to the landlord renovation strategy

Renovation Strategy (Landlord)	House nº1	House nº3	House nº5	House nº13
Energy needs for heating (kWh/y.m²)	153,75	152,31	176,22	90,81
Energy needs for cooling (kWh/y.m²)	4,81	5,09	5,27	4,41
Energy needs for domestic hot water production (kWh/y)	1189	1070	1605	1783
Primary energy (kWhep/y.m²)	515,05	499,02	650,15	447,41
CO_2 emissions (t/year)	2,15	2,08	2,37	2,34
EPC level	D	D	D	C

These houses classified at the F level have improved their EPC ratings. Notably, houses numbered 1, 3, and 5 each increased their ratings by two levels, while house number 13 experienced an enhancement of three levels.

5.2.2 Passive Thermal Comfort Renovation Scenarios

For this dissertation, two renovation scenarios that excluded the use of active equipment were analysed. This passive approach focused on implementing envelope measures, such as insulation and improved building materials, while incorporating a ventilation system to enhance indoor air quality. The strategy aimed to reduce energy consumption by minimising energy demand through passive improvements rather than relying on mechanical systems. It also anticipated that future technological advancements would lead to more efficient equipment, with market prices decreasing over time, making these solutions more accessible and cost-effective in the long term.

Two different scenarios involving envelope measures and ventilation systems are proposed. Both scenarios include isolating the opaque elements, replacing windows and doors with more efficient alternatives, and adding different ventilation systems.

The first scenario includes self-adjustable grills combined with a Ventax extractor fan, providing a basic yet effective approach to enhancing ventilation. The second scenario involves implementing mechanical ventilation with a mechanical ventilation heat recovery (MVHR) system, which offers a more advanced solution that improves ventilation and energy efficiency through heat recovery from exhaust air. These scenarios compare the impact of different ventilation strategies alongside passive envelope improvements.

In this scenario, Houses Nos. 1 and Nos. 3 (Tables 11 and 12) improved their energy performance from an EPC rating of F to B-.

Table 11- Renovation Strategies Incorporating Envelope Improvements and Ventilation Options - House n° 1

House nº 1	**Building Envelope +**		**Existing energy demand of House nº1**
	Self-adjustable grills + Ventax extractor fan	**MVHR**	
Energy needs for heating (kWh/y.m²)	40,02	40,81	258,69
Energy needs for cooling (kWh/y.m²)	4,74	4,75	9,25
Energy needs for domestic hot water production (kWh/y)	1189	1189	1189
Primary energy (kWhep/y.m²)	253,05	249,61	802,47
CO_2 emissions (t/year)	1,06	1,04	3,35
EPC level	**B-**	**B-**	**F**

Table 12- Renovation Strategies Incorporating Envelope Improvements and Ventilation Options- House n° 3

House nº 3	**Building Envelope +**		**Existing energy demand of House nº3**
	Self-adjustable grills + Ventax extractor fan	**MVHR**	
Energy needs for heating (kWh/y.m²)	38,76	38,7	268,88
Energy needs for cooling (kWh/y.m²)	5,1	5,11	8,84
Energy needs for domestic hot water production (kWh/y)	1189	1189	1189
Primary energy (kWhep/y.m²)	250,19	267	828,59
CO_2 emissions (t/year)	1,04	1,11	3,46
EPC level	**B-**	**B-**	**F**

For House No. 1, the implementation of envelope measures and a ventilation system with self-adjustable grills and a bathroom extractor fan resulted in a significant reduction in energy demand, decreasing from 803.46 kWhep/m².year to 253,05 kWhep/m².year. When a Mechanical Ventilation with Heat Recovery (MVHR) system was used, the energy demand decreased slightly, reaching 249.61 kWhep/m².year. Despite this smaller reduction, the MVHR system offers the advantage of recovering heat, which enhances long-term energy efficiency and comfort.

House No. 3 demonstrated a similar outcome, with energy demand decreasing from 828.59 kWhep/m².year to 250.19 kWhep/m².year using the more passive ventilation system with self-adjustable grills. With the MVHR

system, energy demand decreased to 267 kWhep/m².year. Again, while the MVHR system did not provide as large an initial reduction, its heat recovery capabilities offer long-term energy savings and improved indoor climate control.

The CO_2 emissions from both houses in the two scenarios almost reach 1 ton per year.

In these scenarios, Houses Nos. 5 and 13, as shown in Table 13 and Table 14, improved their energy performance from an EPC rating of F to C.

Table 13- Renovation Strategies Incorporating Envelope Improvements and Ventilation Options- House n° 5

House nº 5	**Building Envelope + **		**Existing energy demand of House nº5**
	Self-adjustable grills + Ventax extractor fan	**MVHR**	
Energy needs for heating (kWh/y.m²)	47	49,06	308,80
Energy needs for cooling (kWh/y.m²)	5,27	5,28	10,28
Energy needs for domestic hot water production (kWh/y)	1783	1783	1783
Primary energy (kWhep/y.m²)	377,47	402,01	1021,96
CO_2 emissions (t/year)	1,38	1,47	3,21
EPC level	**C**	**C**	**F**

Table 14- Renovation Strategies Incorporating Envelope Improvements and Ventilation Options- House n° 13

House nº 13	**Building Envelope + **		**Existing energy demand of House nº13**
	Self-adjustable grills + Ventax extractor fan	**MVHR**	
Energy needs for heating (kWh/y.m²)	93,5	101,95	394,47
Energy needs for cooling (kWh/y.m²)	4,4	3,9	8,62
Energy needs for domestic hot water production (kWh/y)	1783	1783	1783
Primary energy (kWhep/y.m²)	493,02	533,8	1245,45
CO_2 emissions (t/year)	1,79	1,93	4,5
EPC level	**C**	**C**	**F**

For House No. 5, implementing envelope measures, a ventilation system with self-adjustable grills, and a bathroom extractor fan led to a significant decrease in energy demand, dropping from 1,021.96 kWhep/m²/year to 377.47 kWhep/m²/year. When a Mechanical Ventilation with Heat Recovery (MVHR) system was utilised, the energy demand decreased slightly to 402.01 kWhep/m²/year. Although the reduction was smaller with the MVHR system, its ability to recover heat offers long-term energy efficiency and occupant comfort benefits.

House No. 13 saw a significant improvement in energy efficiency. The energy demand decreased from 1245,45 kWhep/m²/year to 493,02 kWhep/m²/year by using a passive ventilation system with self-adjustable grills. When the MVHR system was used, the energy demand was reduced to 533.8 kWhep/m²/year.

Regarding CO_2 emissions, House No. 5 saw reductions to 1,38 tonnes per year with the passive system and 1.47 tonnes per year with the MVHR system. For House No. 13, emissions were reduced to 1,79 tonnes per year with self-adjustable grills and 1.93 tonnes per year with the MVHR system.

5.2.3 iBRoad2EPC Renovation Strategy

All the above-proposed renovation scenarios are benchmarks for evaluating and comparing results with the iBRoad2EPC renovation passport. The iBRoad2EPC framework offers a structured, step-by-step strategy to engage stakeholders in achieving more comprehensive outcomes. This approach aligns with climate goals by promoting the decarbonisation of buildings while addressing the inherent complexities of renovation projects.

By comparing the outlined renovation scenarios to the iBRoad2EPC framework, stakeholders can evaluate how each strategy performs regarding energy efficiency, decarbonisation, and practicality. This comparison helps identify the most effective path forward, ensuring that the selected approach meets immediate needs and aligns with long-term sustainability and climate resilience goals.

The renovation timelines for the four houses vary based on their specific needs. Immediate measures first address the most urgent issues, prioritising ventilation systems and envelope insulation. As previously explained, heating and DHW replacements are reserved for the final stages.

House nº 1

Table 15 outlines the renovation strategy for house number 1.

Firstly, an immediate action plan (ASAP phase) was to replace the inoperable windows and the ventilation system. Looking ahead to 2030, it was proposed that the showers should be replaced with more efficient

models in anticipation of the house having an indoor bathroom. It also included the new LED lighting system. By 2040, the insulation of the interior walls and the ground is proposed, two measures that can be carried out simultaneously. For 2050, heating equipment is proposed, including a pellet stove and a heat pump for DHW.

Table 15- Renovation Strategy for House °1

iBRoad2EPC Renovation Strategy - House nº 1		**iBRoad2EPC**			
		ASAP	**2030**	**2040**	**2050**
BUILDING ENVELOPE	Thermal insulation- Roof 10cm Rockwool		x		
	Thermal insulation- Ext walls 10cm of EPS	x			
	Thermal insulation - Int walls 8cm of rock wool + plas-terboard			x	
	Thermal insulation of the ground floor 4cm XPS			x	
	Replacement of the existing windows for double-glazed PVC windows	x			
	New wooden door	x			
EQUIPAMENTS	Self-adjustable grills + Ventax extractor fan	x			
	Replacement of showers for water-efficient shower systems				x
	LED lighting installation		x		
	Pellet stove				x
	Heat pump for DHW				x

Table 16 summarises the EPC calculation results of the passport's four steps, demonstrating the reduction of energy demand over time, CO_2 emissions and improvement of the EPC rate.

The results on Tabel 16 reveal the reduction in primary energy needs (ASAP step) – initially —from 803.46 to 701.71 kWhep/y.m² — does not significantly improve the building energy performance. By 20230, energy demand could decrease to 544.79 kWhep/y.m², enough for an E rating. By 2040, the improvements will lead to a B- rating with a demand of 253,05 kWhep/y.m². Ultimately, the stepwise renovation results in an A rating, with a demand of just 36,23 kWhep/y.m².

CO_2 emissions are notably reduced, from 2.93 to 0.17 t/year by 2050.

Table 16- Energy needs House n° 1

iBRoad2EPC Energy needs - House nº 1	**iBRoad2EPC**				**Existing energy demand of House nº1**
	ASAP	**2030**	**2040**	**2050**	
Energy needs for heating (kWh/y.m²)	217,46	156,84	40,02	72,79	258,69
Energy needs for cooling (kWh/y.m²)	10,83	4,39	4,74	2,07	9,25
Energy needs for domestic hot water production (kWh/y)	1189	1189	1189	1070	1189
Primary energy (kWhep/y.m²)	701,71	544,79	253,05	36,23	803,47
CO_2 emissions (t/year)	2,93	2,27	1,06	0,16	3,35
EPC level	**F**	**E**	**B-**	**A**	**F**

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House nº 3

Table 17 reveals the renovation strategy for House No. 3. Despite the absence of visible mould, it was recommended that the roof be insulated and the ventilation system be enhanced. The plan also included installing a new LED lighting system in this first step (ASAP).

The proposal was to renovate the envelope by 2030 by insulating the exterior walls, replacing the current windows with double-glazed windows, and installing a new door.

In the 2040 step, it was proposed to partially insulate the interior wall while respecting the tenants' desire to keep an exposed granite wall. Insulation was added to the ground floor, and a pellet stove was installed as a heating system.

For 2050, a heat pump for DHW is proposed, as well as the replacement of showers for water-efficient shower systems.

In the first step, there was a reduction in the energy demand of the building from an initial 828.59 kWhep/y.m² to 641.77 kWhep/y.m², moving from an initial F class to an E class. By 2030, the energy demand will drop further to 534.05 kWhep/y.m², achieving a D rating with the proposed improvements. By 2040, a B- rating is achieved with an energy demand of 153.27 kWhep/y.m², ultimately reaching an A+ rating with a demand of 28.1 kWhep/y.m² in 2050. The information is clearly presented in Table 18.

It is important to highlight that CO_2 emissions will drop considerably from 2,69 t/year to 0,64 t/year by 2040 and to 0,12t/year by the end of 2050.

Table 17- Renovation Strategy House n° 3

iBRoad2EPC Renovation Strategy - House nº 3		**iBRoad2EPC**			
		ASAP	**2030**	**2040**	**2050**
BUILDING ENVELOPE	Thermal insulation- Roof 10cm Rockwool	x			
	Thermal insulation- Ext walls 10cm of EPS		x		
	Thermal insulation - Int walls 8cm of rock wool + plasterboard			x	
	Thermal insulation of the ground floor 4cm XPS			x	
	Replacement of the existing windows for double-glazed PVC windows		x		
	New wooden door		x		
EQUIPAMENTS	Self-adjustable grills + Ventax extractor fan	x			
	Replacement of showers for water-efficient shower systems				x
	LED lighting installation	x			
	Pellet stove			x	
	Heat pump for DHW				x

Table 18- Energy needs House n° 3

iBRoad2EPC Energy needs - House nº 3	**iBRoad2EPC**				**Existing energy demand of House nº3**
	ASAP	**2030**	**2040**	**2050**	
Energy needs for heating (kWh/y.m²)	197,1	152,31	63,96	63,96	268,88
Energy needs for cooling (kWh/y.m²)	3,82	5,09	5,08	5,09	8,84
Energy needs for domestic hot water production (kWh/y)	1189	1189	1189	1070	1189
Primary energy (kWhep/y.m²)	641,77	534,05	153,27	28,1	828,59
CO_2 emissions (t/year)	2,69	2,23	0,64	0,12	3,46
EPC level	**E**	**D**	**B-**	**A+**	**F**

House nº5

For House No. 5 (Table 19), the initial proposal addressed deteriorated flooring through proper insulation and the appropriate pavement replacement. Additionally, the proposal included insulating the roof and improving the ventilation system to enhance indoor air quality. A new lighting solution with LEDs was also proposed.

The proposed measures for 2030 include insulating the exterior walls and replacing the existing windows with more energy-efficient alternatives. Additionally, the proposal involved installing a new wooden door to further enhance the building's thermal performance and sustainability.

The renovation strategy proposed for 2040 suggests adding insulation to the interior walls, implementing energy-efficient showers if a bathroom is incorporated within the house, and installing a heat pump to provide DHW. These measures aim to further improve the building's energy efficiency and sustainability.

The proposed renovation plan for 2050 includes installing a biomass heating system, which would further enhance the building's sustainability by utilising renewable energy sources.

Table 19- Renovation Strategy- House n°5

	iBRoad2EPC Renovation Strategy - House nº 5	**iBRoad2EPC**			
		ASAP	**2030**	**2040**	**2050**
BUILDING ENVELOPE	Thermal insulation- Roof 10cm Rockwool	x			
	Thermal insulation- Ext walls 10cm of EPS		x		
	Thermal insulation - Int walls 8cm of rock wool + plasterboard			x	
	Thermal insulation of the ground floor 4cm XPS	x			
	Replacement of the existing windows for double-glazed PVC windows		x		
	New wooden door		x		
EQUIPAMENTS	Self-adjustable grills + Ventax extractor fan	x			
	Replacement of showers for water-efficient shower systems			x	
	LED lighting installation				x
	Pellet stove				x
	Heat pump for DHW			x	

The comparative analysis of energy demand for house No. 5 is shown in Table 20. The immediate intervention (ASAP) reduces House No. 5's energy needs from 1,021.96 kWhep/m².year to 843.19 kWhep/m².year, re-

sulting in a change from an EPC rating of F to E. By 2030, the energy performance improves to a D, with energy consumption decreasing to 686.33 kWhep/m².year. In 2040, the EPC level reaches B, with an energy consumption of 167.04 kWhep/m².year, and by 2050, the house will attain an A rating, with a significantly reduced energy demand of 45.31 kWhep/m².year.

The CO_2 emissions for House No. 5 are projected to decrease from 3.03 tons per year to 2.5 tons per year by 2030. By 2040, emissions are expected to drop to 0.61 tons per year. By 2050, they will reach a minimal level of 0.17 tons per year, reflecting the impact of the proposed energy efficiency measures and the energetic transition.

Table 20- Energy needs House n°5

iBRoad2EPC Energy needs - House nº 5	**iBRoad2EPC**				**Existing energy demand of House nº5**
	ASAP	**2030**	**2040**	**2050**	
Energy needs for heating (kWh/y.m²)	240,72	176,22	48,69	47	308,80
Energy needs for cooling (kWh/y.m²)	4,5	5,27	5,27	5,27	10,28
Energy needs for domestic hot water production (kWh/y)	1783	1783	1605	1605	1783
Primary energy (kWhep/y.m²)	843,19	686,33	167,04	45,31	1021,96
CO_2 emissions (t/year)	3,09	2,5	0,61	0,17	3,21
EPC level	**E**	**D**	**B**	**A**	**F**

House nº 13

House No. 13 exhibited the highest energy demand, at 1,245.45 kWhep/m².year, and did not transition to a lower energy performance level following the initial ASAP step, which included roof and floor insulation. Despite this, the ventilation system was enhanced to improve indoor air quality, and it was also proposed that LED lighting be incorporated to reduce electricity consumption. However, these measures were insufficient to significantly alter the house's energy classification at this stage but decreased the value of energy demand to 1133,47kWhep/m².year. Table 21 and Table 22

In 2030, House No. 13 will upgrade to double-glazed windows and insulated exterior walls, improving its EPC rating to C and reducing its energy demand to 531.04 kWhep/m².year.

By 2040, the pellet stove will lower the energy demand to 259,27 kWhep/m².year, achieving a B- rating. Finally, by 2050, the house will reach an A+ rating with an energy demand of 54,41 kWhep/m².year.

CO_2 emissions will decrease from 4.09 tons/year to 0.21 tons/year.

Table 21 outlines the sequence of renovation measures for House No. 13 across the various steps of the passport. Table 22 shows the results obtained for the renovation measures, i.e., energy needs for heating, cooling, DHW, and annual primary energy.

Table 21- Renovation Strategy House n°13

iBRoad2EPC Renovation Strategy nº 13		**iBRoad2EPC**			
		ASAP	**2030**	**2040**	**2050**
BUILDING ENVELOPE	Thermal insulation- Roof 10cm Rockwool	x			
	Thermal insulation- Ext walls 10cm of EPS		x		
	Thermal insulation of the floor 10 cm of EPS	x			
	Replacement of the existing windows for double-glazed PVC windows		x		
EQUIPAMENTS	Self-adjustable grills + Ventax extractor fan	x			
	Replacement of showers for water-efficient shower systems			x	
	LED lighting installation	x			
	Pellet stove			x	
	Heat pump for DHW				x

Table 22- Energy needs House n°13

iBRoad2EPC Energy needs - House nº 13	**iBRoad2EPC**				**Existing energy demand House nº13**
	ASAP	**2030**	**2040**	**2050**	
Energy needs for heating (kWh/y.m²)	349,88	108,71	97,25	97,25	394,47
Energy needs for cooling (kWh/y.m²)	5,63	5,51	4,17	4,17	8,62
Energy needs for domestic hot water production (kWh/y)	1783	1783	1605	1605	1783
Primary energy (kWhep/y.m²)	1133,47	531,04	259,32	54,41	1245,45
CO_2 emissions (t/year)	4,09	1,93	0,85	0,21	4,5
EPC level	**F**	**C**	**B-**	**A+**	**F**

The analysis in Table 23 indicates that all proposed renovation strategies are connected to an EPC rating, especially when evaluating the building's current performance and offering suggestions for enhancement. These strategies enhance energy efficiency and align the building's energy consumption with targeted EPC levels.

Table 23- EPC Ratings for All Renovation Strategies by House

Renovation Strategy EPC rating	**EPC Current state**	**iBRoad2EPC**				**Landlord**	**Envelope + ventila-tion**	**Envelope + MVHR**
		ASAP	2030	2040	2050			
House nº1	F	F	E	B-	A	D	B-	B-
House nº3	F	E	D	B-	A+	D	B-	B-
House nº5	F	E	D	B	A	D	C	C
House nº13	F	F	C	B-	A+	C	C	C

5.3 Energy savings

EU policy provides Member States with a framework to reduce emissions from the built environment while improving the quality of life for citizens. To achieve these goals, it is essential to address the energy demand of the existing building stock. At the same time, standards for residential buildings must ensure that the average primary energy consumption of the housing stock decreases progressively over the years, with the ultimate aim of decarbonising the building sector by 2050. This gradual reduction in energy demand is crucial for meeting the EU's long-term sustainability and climate objectives.

House nº1

Table 24 shows the energy savings for different scenarios of House No. 1. The ASAP step will nearly achieve the milestone of reducing energy consumption by 16% by 2030, according to the provisions of the EPBD re-cast. By that year, the building had already reached a 32% reduction compared to its original energy consump-tion. Although the definition of deep renovation has evolved in the EPBD, if we consider the previous standard of 60% energy savings, this target will be achieved by 2040. By 2050, the house will attain NZEB status, in line with current Portuguese legislation, with a 95% reduction in energy demand.

Considering the building envelope renovation strategy with the two types of ventilation, the existing conditions will still be significantly improved. Both show a reduction of over 60%, with similar values (71% and 69%).

The renovation plan outlined by the landlord results in only a 36% reduction in energy consumption.

Table 24- Energy Savings House n°1

Energy savings House nº 1	iBRoad2EPC				Landlord	Building Envelope	
	ASAP	2030	2040	2050		Self-adjustable grills + Ventax extractor fan	MVHR
% reduction in primary energy compared to the existing energy certificate	13	32	69	95	36	69	69
Regulation targets	>16% 2030	>22% 2035	>60% deep renovation	NZEB		>60% deep renovation	>60% deep renovation

House nº3

For House No. 3, the proposed measures in the ASAP step achieve a 23% reduction in primary energy compared with the existing energy certificate, complying with the 16% by 2030 EPBD milestone. In 2030, the building is projected to reach a 36% reduction, substantially more than the required 22% by 2035. In 2040, an 82% reduction in energy consumption will be achieved. By 2050, the house will attain NZEB status.

The building envelope renovation measures, equipped with ventilation systems, also reduce primary energy consumption by 70% and 68% in the two ventilation options.

From the landlord's perspective, the building refurbishment only results in a 40% reduction in energy demand.

All of these results are summarised in Table 25.

Table 25- Energy Savings House n°3

Energy savings House nº 3	iBRoad2EPC				Landlord	Building Envelope	
	ASAP	2030	2040	2050		Self-adjustable grills + Ventax extractor fan	MVHR
% reduction in primary energy compared to the existing energy certificate	23	36	82	97	40	70	68
Regulation targets	>16% 2030	>22% 2035	>60% deep renovation	NZEB		>60% deep renovation	>60% deep renovation

House nº5

Table 26 indicates the energy savings and met regulation targets. In House n°5 the initial phase of the renovation plan achieves a 17% decrease in primary energy consumption, surpassing the 2030 target by 1%. In the subsequent phase, the energy reduction increases to 33%, surpassing the regulatory requirements in 2035. By 2040, the reduction reaches 84%, and by 2050, the house qualifies as a nearly zero-energy building (NZEB) with a 96% reduction in energy demand. The renovation strategies for the building envelope with only a ventilation system closely align with the previously defined "deep renovation" goal of a 60% reduction.

Based on the landlord's renovation approach, only a 36% reduction in energy consumption is anticipated.

Table 26- Energy Saving House n° 5

Energy savings House nº 5	**iBRoad2EPC**				**Landlord**	**Building Envelope**	
	ASAP	**2030**	**2040**	**2050**		**Self-adjustable grills + Ventax extractor fan**	**MVHR**
% reduction in primary energy compared to the existing energy certificate	17	33	84	96	36	63	61
Regulation targets	>16% 2030	>22% 2035	>60% deep renovation	NZEB		>60% deep renovation	>60% deep renovation

House nº 13

In the initial phase of this renovation strategy, the anticipated energy savings are modest, achieving only a 9% reduction. However, in the subsequent phase, a significant improvement is observed, with energy demand reduction increasing to 57%, surpassing the milestones of a 16% reduction by 2030 and a 22% reduction by 2035. By 2040, the cumulative improvements enable the building to achieve a reduction of over 60% in energy demand, with the ultimate goal of attaining NZEB status by 2050.

Enhancements in the building envelope and advanced ventilation systems are pivotal to this improvement, contributing to approximately 60% savings in overall energy consumption.

Furthermore, the landlord's initiatives are projected to reduce energy usage by 55%, underscoring the significance of comprehensive renovation strategies encompassing structural improvements and management practices in achieving substantial energy efficiency gains. The analysis of the energy savings values is included in Table 27.

Table 27- Energy savings in House n° 13

Energy savings House nº 13	iBRoad2EPC				Landlord	Building Envelope	
	ASAP	2030	2040	2050		Self-adjustable grills + Ventax extractor fan	MVHR
% reduction in primary energy compared to the existing energy certificate	9	57	83	96	55	64	57
Regulation targets		>22% 2035	>60% deep renovation	NZEB		>60% deep renovation	>60% deep renovation

5.4 Investment Costs

Accurately assessing the investment requirements before undertaking a deep renovation of a building is crucial. This approach, combined with implementing a renovation passport, helps to effectively mitigate the risk of lock-in effects, ensuring that renovation measures are strategic and align with long-term energy efficiency goals. Planning comprehensively maximises the building's potential for future improvements without requiring costly or inefficient retrofits later.

In the analysis of investment costs (Table 28), the landlord's contribution is the lowest because it only includes the most basic necessary measures, focusing on minimal compliance rather than enhancing the comfort of the tenants. From an investor's perspective, the landlord prioritises cost efficiency, opting for standard construction interventions such as roof and external wall insulation and window replacement. The landlord selects the lowest-cost options for equipment upgrades, disregarding more advanced or tenant-comfort-focused solutions. This cost-driven approach limits the potential for improving building performance and tenant well-being.

From the iBRoad2EPC renovation passport analysis, the investment, although spread out over time until 2050, is almost 60% higher than the landlord's investment despite the co-benefits in improved construction quality.

When considering the envelope renovation strategy combined with a passive ventilation system (self-adjustable grills and an extractor fan), the investment is about 40% higher than the landlord's baseline investment but 37% lower than the iBRoad2EPC passport costs.

Although the well-known benefits of a Mechanical Ventilation with Heat Recovery (MVHR) system are significant, from a cost-effectiveness standpoint, MVHR remains an expensive technology, particularly in renovations for low-income households or from a landlord's perspective focused on minimal investments.

Table 28- Investment Costs

Investment costs	iBRoad2EPC					Landlord	Building Envelope	
	ASAP	2030	2040	2050	TOTAL		Self-adjustable grills + Ventax extractor fan	MVHR
House n°1	1 929,32 €	3 560,04 €	3 797,29 €	5 450,36 €	14 737,01 €	6 404,91 €	9 207,33 €	11 388,32 €
House n°3	3 656,39 €	1 996,09 €	5 459,34 €	2 919,48 €	14 031,30 €	6 858,09 €	9 156,40 €	11 433,74 €
House n°5	4 064,15 €	1 914,53 €	6 309,01 €	2 994,00 €	15 281,69 €	6 486,47 €	9 288,89 €	11 469,88 €
House n°13	6 973,37 €	7 233,09 €	2 919,48 €	2 994,00 €	20 119,94 €	13 031,11 €	12 190,04 €	14 371,03 €

5.5 Indoor Environmental Quality

The iBRoad2EPC - IEQ module was used to assess IEQ as part of the renovation process. While evaluating comfort levels from an individual perspective can be complex, this tool offers valuable insights by comparing the current conditions of the building with the proposed improvements outlined in the renovation passport. The rating scale ranges from 1 to 10, with the following categories: "Very poor" (0 - <2), "Bad" (2 - <4), "Acceptable" (4 - <6), "Good" (6 - <8) and "Excellent" (8 - <10).

The iBRoad2Epc platform features an IEQ page that displays the IEQ levels based on the renovation strategy outlined in the passport at each process step.

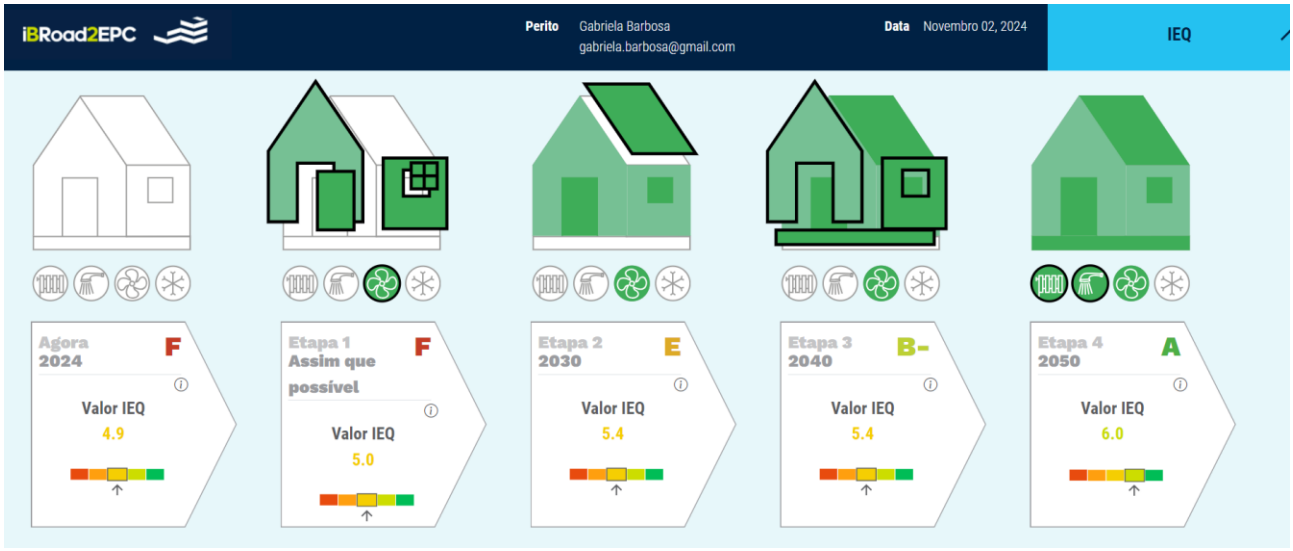


Figure 32 - IEQ module - House nº1

iBroad2EPC Assistant

House No. 1 (Figure 32) has an initial Indoor Environmental Quality (IEQ) rating of 4.9, corresponding to an "Acceptable" level. Over time, this rating gradually improves, eventually reaching the minimum threshold for a "Good" rating.

For House No. 3 (Figure 33), the initial IEQ rating is 4.9, which falls within the "Acceptable" category. After implementing the proposed renovation measures, the IEQ improves to 6.0, moving into the "Good" category.

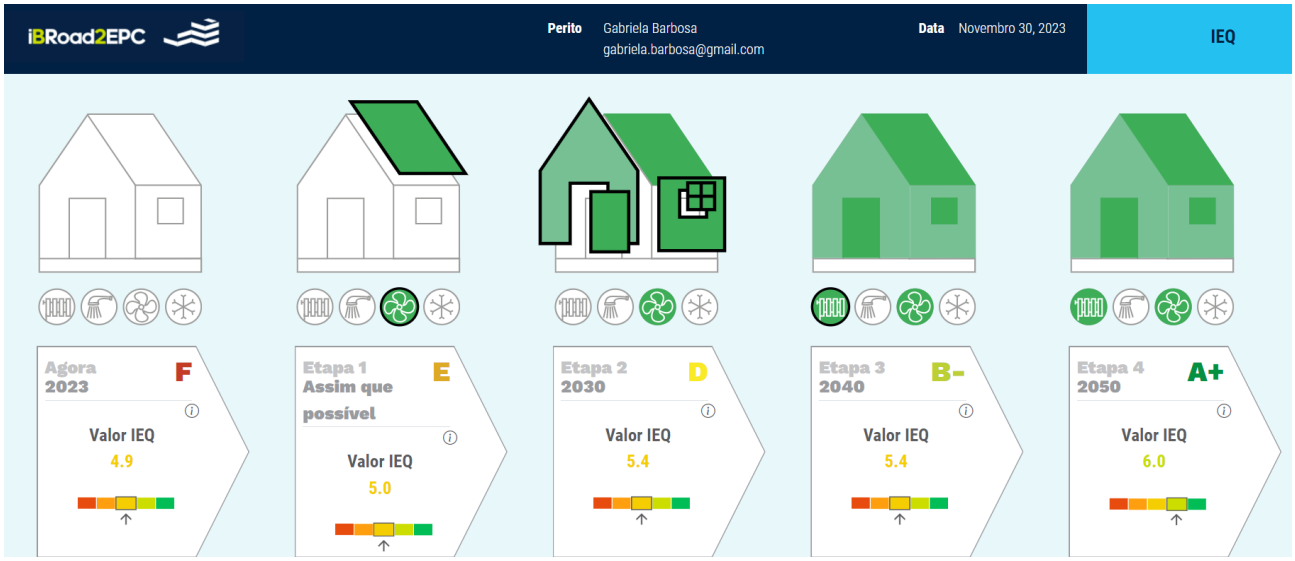


Figure 33- IEQ module - House nº3

iBroad2EPC Assistant

House No. 5 (Figure 34) has increased its comfort rating from 3.7 to 5.1, moving from a “Bad” level to “Acceptable” with a new rating of 5.1.



Figure 34- IEQ module – House nº 5

iBRoad2EPC Assistant

Similarly, in House No. 13 (Figure 35), the existing conditions provide an IEQ rating of 4.1, also deemed "Acceptable". Following the renovations, the IEQ rises to a score of 6.0, achieving a "Good".

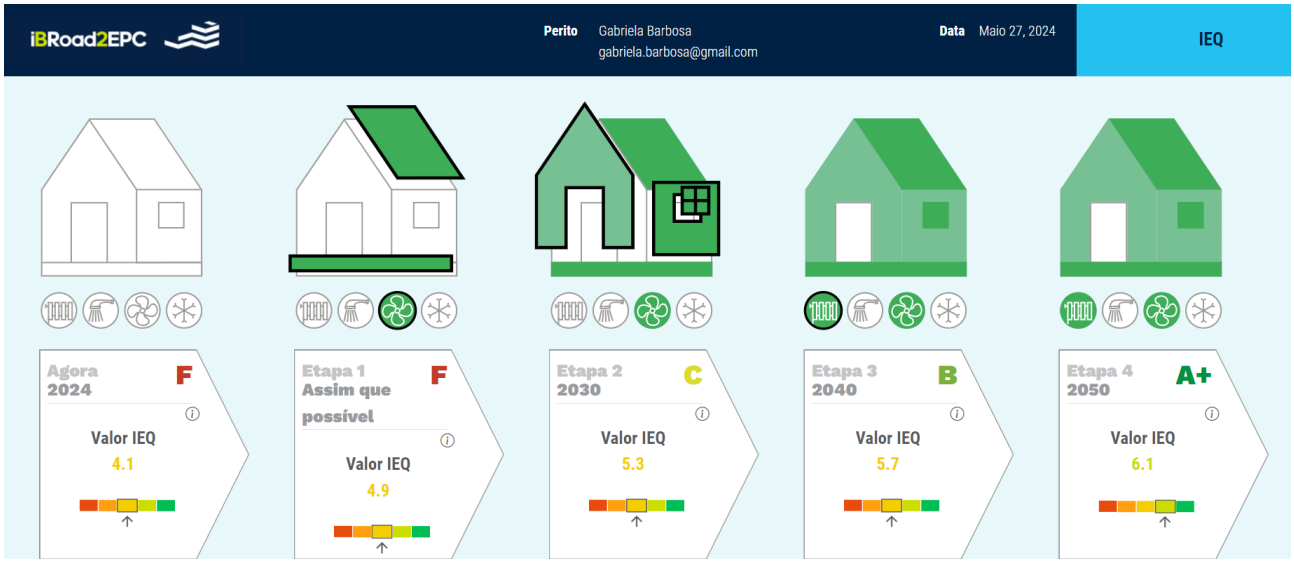


Figure 35- IEQ module – House n° 13

iBRoad2EPC Assistant

5.6 iBroad2EPC Passport

Once all the planned renovation measures for the building are assigned to the appropriate renovation steps and the related recommendations are generated, the basic iBRoad2EPC is completed.

The renovation passport overview document is presented in an engaging and visually appealing format, summarising all key entries, including renovation measures, project details, building images, and the efficiency class. The following images display the BRP for each house, outlining the proposed renovation strategy. They detail the renovation measures recommended by the issuer, assigned to specific renovation steps, and the corresponding recommendations. The document also highlights the EPC rating and includes an energy demand module, illustrating the final primary energy needs after each step.

This comprehensive presentation clearly demonstrates the impact of each measure on the building's performance and the associated energy savings. By providing this detailed information, the renovation passport empowers building owners with the insights needed to make informed decisions about undertaking renovations.

House nº 1

The renovation strategy for House No. 1 spans until 2050, beginning with an initial EPC rating of F and progressing to an A rating by the end of the timeline. In the visual representation, the house symbol is shown in white, while the renovation measures implemented at each step, reflecting the upgrades to building components aligned with the targets, are highlighted in green, as displayed in Figure 36.



Figure 36 – House n° 1 Preview of the iBRoad2EPC: overview page for building owners

Figure 37 illustrates the energy demand and CO_2 emissions after each renovation step and information about the energy sources utilised.

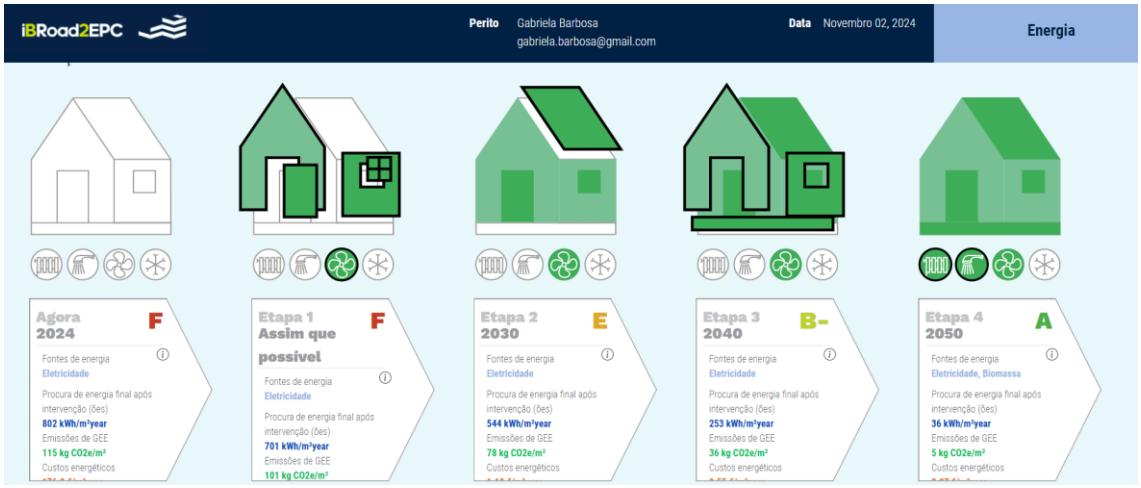


Figure 37 - House n° 1 Output page of the Energy Demand module in the online version in the output document of iBRoad2EPC.

House nº 3

The information for House n° 3 is presented similarly. Figure 38 illustrates the renovation timeline, detailing each renovation measure and the corresponding Energy Performance Certificate (EPC) levels. Meanwhile, Figure 39 shows the primary energy consumption following each renovation, along with the associated greenhouse gas emissions and energy supply.

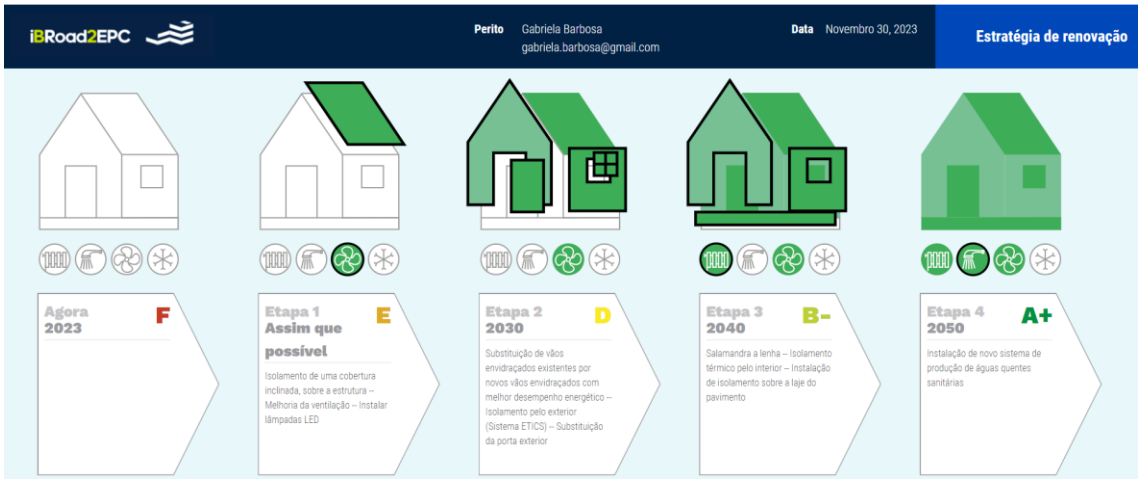


Figure 38- House n° 3 Preview of the iBRoad2EPC: overview page for building owners

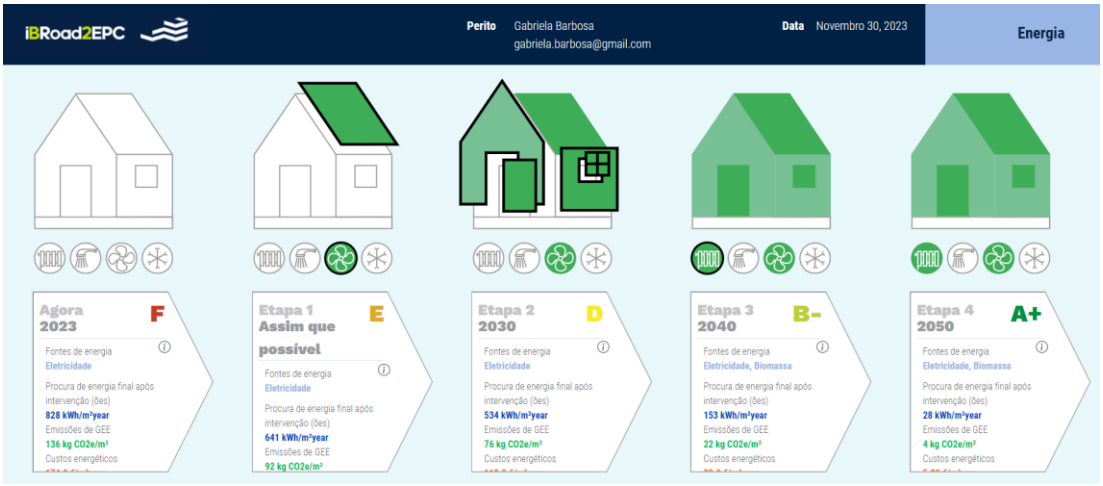


Figure 39- House n° 3 Output page of the Energy Demand module in the online version in the output document of iBRoad2EPC.

House nº 5

The iBRoad2EPC passport for House No. 5 contains the same information as the previous houses. Figure 40 illustrates an overview of the passport, while Figure 41 shows the energy demand for each renovation step.



Figure 40 - House n° 5 Preview of the iBRoad2EPC: overview page for building owners

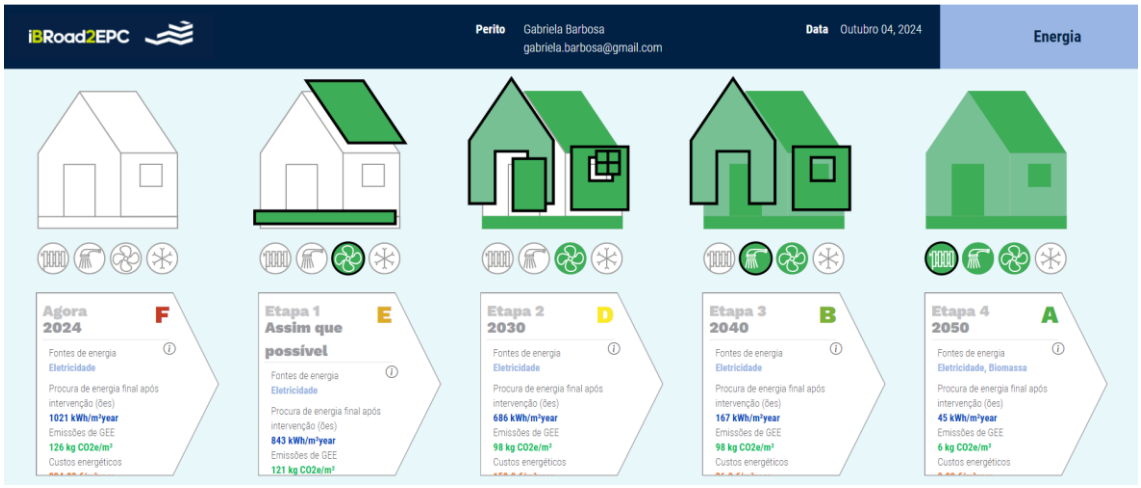


Figure 41 - House n° 5 Output page of the Energy Demand module in the online version in the output document of iBRoad2EPC.

House nº 13

Figures 42 and 43 present House n° 13 Passport's information similar to that of the previous houses.



Figure 42- House n° 13 Preview of the iBRoad2EPC: overview page for building owners

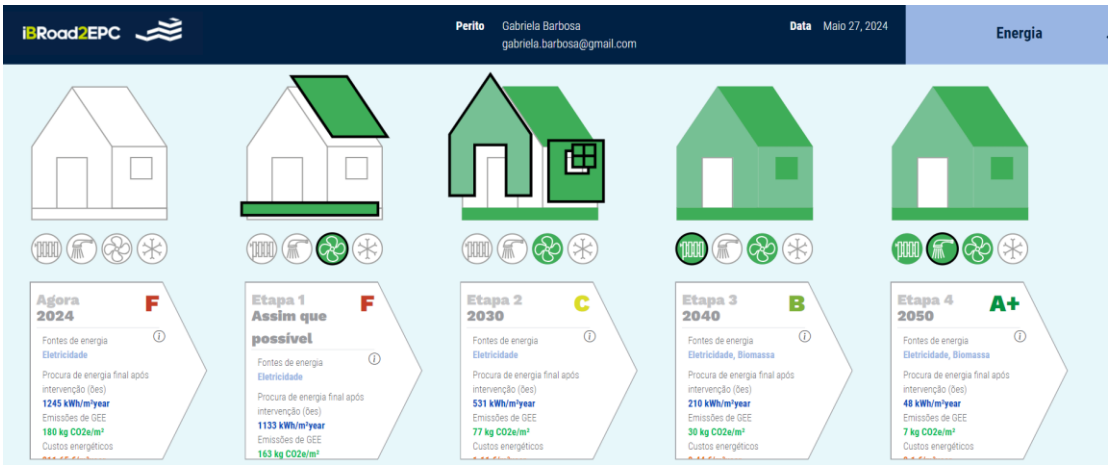


Figure 43- House n° 13 Output page of the Energy Demand module in the online version in the output document of iBRoad2EPC

The Annexes include complete information for each iBRoad renovation passport and provide a detailed overview of the webpage platform. They also include the EPCs for each house, generated using the ITECONS software in XML format. These files were imported into the Portuguese Platform for Building Efficiency (ADENE) to ensure national energy certification standards compliance.

The analysis of the results shows that simply insulating the opaque envelope of buildings is inadequate to achieve an energy rating above class C. The ventilation systems provide the necessary indoor air quality, and to meet the occupant's needs, it's not necessary to have an expensive system. Self-adjustable grills and a simple Ventax extractor fan are inexpensive solutions that can resolve dampness and mould issues. It's also important to address the hydric efficiency and provide the replacement of shower systems. To ensure thermal comfort in these homes, it is essential to introduce a biomass heating system. Additionally, using renewable energy systems for on-site electricity generation may not always be feasible. Therefore, alternatives, such as energy sharing through energy communities, could help provide energy supply to vulnerable families. The study also indicates that the costs associated with energy retrofitting to achieve a higher efficiency rating can be prohibitively expensive for tenants and may not be a priority investment for landlords.

This dissertation highlights the effectiveness of tailored renovation strategies that account for buildings' technical characteristics and the specific needs of occupants and landlords. The proposed interventions address urgent issues such as dampness, mould, and inadequate insulation while balancing long-term energy efficiency goals with financial feasibility and regulation targets. Notably, the timeline for implementing advanced technologies, such as heat pumps and photovoltaic panels, reflects the evolving landscape of energy solutions, allowing for future cost reductions and technological improvements.

6. DISCUSSION AND MAIN FINDINGS

This Discussion section presents an in-depth analysis of the findings, placing them in context and reflecting on their implications. The goal is to interpret the results per the research question, existing literature, and the broader field of study.

Key findings

This research evaluates the impact of BRP strategies on enhancing energy efficiency in low-income households by applying the iBRoad2EPC passport. It seeks to develop tailored BRP to upgrade housing conditions by addressing individual needs and creating a roadmap specifying improvement measures, anticipated energy use, costs, and expected comfort levels.

The study explores the role of BRP in guiding the selection of renovation interventions, aiming to achieve a balance between decarbonisation, occupant preferences, and financial constraints.

The findings suggest that effective energy efficiency measures can significantly improve a building's performance. Even the prescribed roadmap's initial step (ASAP) can achieve an over 16% reduction in energy consumption. This aligns with the requirements of the EPBD, which mandates that Member States establish their renovation trajectory for the period between 2020 and 2030.

The recast EPBD requires all Member States to establish a national trajectory for the progressive renovation of the residential building stock from 2020 to 2050. This trajectory aims to decrease the average primary energy use to a specified level (kWh/m^2/year). Member States must ensure that the average primary energy use of the residential stock decreases by at least 16% between 2020 and 2030.

The analysis shows that investing in standard construction interventions without considering energy efficiency does not achieve the required energy demand reductions in the building sector. Choosing the lowest-cost options restricts the potential for enhancing building performance and occupants' well-being.

The results indicate that improvements to the building envelope and an upgraded ventilation system can serve as an effective initial strategy, paving the way for the eventual integration of more complex or costly technologies. Additionally, the analysis demonstrates that even implementing a few passive measures can significantly enhance overall building performance.

To meet the building sector's decarbonisation targets, it is essential to adopt highly efficient equipment for DHW and heating and cooling systems, ideally powered by renewable energy sources, to achieve NZEB standards and, in the future, zero-emissions building standards.

The iBRoad2EPC renovation passport enables a clear and straightforward assessment of results, making it easier for owners and tenants to understand the proposed renovation measures and their expected outcomes. It also provides a clear view of the gradual upgrade in EPC and IEQ levels over time.

Additionally, the iBRoad2EPC assistant simplifies the process of developing and evaluating various deep renovation proposals, offers a structured path toward comprehensive energy efficiency upgrades, and facilitates the issuer's development of the BRP.

The research also emphasises that investment costs can be a significant barrier for landlords who are hesitant to invest in energy-efficient measures, especially when it's difficult to justify the return on investment in low-income households. Furthermore, evictions related to renovations present additional challenges. From the tenants' perspective, they are unlikely to invest in improvements for a property they do not own.

Given these insights, focusing on financial strategies that encourage energy-efficient decisions is crucial, particularly to combat energy poverty during the shift towards sustainability. Policymakers should introduce specific financial aid for low-income households, making energy-saving solutions more reachable and economically feasible (Della Valle et al., 2024).

Energy policies have largely overlooked the challenges the rented sector faces, which comprise approximately 30% of the EU population in 2021 (Statistics | Eurostat, n.d.). A review of policies in developed countries reveals few examples of targeted support for tenants and landlords. Studies indicate that most existing policies emphasise technical and financial measures, while relatively few address behaviour change and energy conservation initiatives (Bouzarovski et al., 2020).

According to the literature, the primary triggers for renovation are typically the need for maintenance, replacement of defective components, availability of funds, or addressing health issues. For occupants, particularly low-income families, the most important aspects of energy renovation are not primarily energy savings but improving comfort and health within the home (Directorate-General for Energy, 2019).

The EU recognises that EPCs, BRP, and supplementary support instruments such as One-Stop shops can play a crucial role in facilitating renovations and improving access to financing, thereby addressing existing barriers. The recast EPBD 2024 introduces a dedicated article on one-stop shops, enhancing their visibility as essential information and advisory resources for renovation. These alliances are expected to increase the utilisa-

tion of one-stop shops. Furthermore, EPCs and BRPs must now include contact information for relevant one-stop shops as a mandatory component.

Promoting step-by-step deep renovations through One-Stop shops, supported by appropriate financing mechanisms, can attract more financially constrained homeowners. Additionally, clustering homes needing renovation and implementing effective energy or carbon pricing strategies could enhance the attractiveness of the renovation market for investors and construction companies (Mainali et al., 2021). Establishing local One-Stop shops can further reduce transaction costs, address information gaps—such as a lack of knowledge about available financing options or tailored refurbishment advice—and offer integrated solutions for building renovations.

Empowering energy-poor individuals to transition into active energy citizens is still in its early stages, primarily driven by policymakers, local authorities, intermediaries, and grassroots initiatives. However, these actors often face limited financial resources, knowledge, and time constraints. Therefore, continued efforts are needed to empower them to create the conditions for the widespread adoption of these empowerment mechanisms. This transition from passive consumer to energy citizen can also lay the groundwork for addressing broader issues of energy injustice (DellaValle & Czako, 2022).

Existing research shows that traditional one-size-fits-all policies and interventions do not effectively reach significant population groups (Sequeira et al., 2024). In this context, BRPs could serve as valuable tools for both information and empowerment, fostering bottom-up solutions that enable citizens to make more informed energy consumption and investment decisions.

This dissertation could not incorporate clean energy production into developing the renovation strategy for this case study. Most roofs are oriented towards the Northeast, with only House Number 13 presenting viability. However, even this has limited space for photovoltaic panels. For that reason, integration into a Renewable Energy Community (REC) could fulfil an alternative pathway to increased energy security while reducing dependencies on fossil fuel energy. Integrating local energy generation can enhance affordability, promote the shift to renewable sources, and reduce market volatility.

At the same time, DellaValle & Czako, 2022, highlight that for vulnerable groups to participate in and use collective energy schemes, barriers such as limited financial resources, knowledge, and technical assistance still need to be overcome.

It is also important to address energy sufficiency for future studies. According to the authors Della Valle et al., 2024, policymakers can address climate change by promoting energy sufficiency and efficiency. Energy suffi-

ciency involves reducing energy service demand to ensure well-being within planetary boundaries. Energy-efficient technologies can lead to an increase in consumption. Energy sufficiency provides an alternative approach to the energy transition, recognising the need to reduce total energy consumption while achieving high levels of global human development (Burke, 2020).

The level of building energy efficiency is closely linked to occupant demand and behaviour, which encompasses daily routines, occupancy patterns, and individual preferences for building services. Further research is necessary to explore behaviour change and the integration of bioclimatic design principles. Implementing energy efficiency measures can help mitigate costs, provide benefits during extreme weather events, and alleviate the impacts of future energy crises (Hu et al., 2023).

The primary value of a BRP concept lies in its potential to significantly improve the quality of EPCs and enhance the effectiveness and acceleration of deep renovation interventions. Financial and non-financial incentives are crucial for facilitating these deep renovations, often involving substantial costs. By integrating BRP into incentive programs, their effectiveness can be improved through the following measures:

- Establishing clearer guidelines for public administrations regarding which renovation interventions should be prioritised for incentives;
- Linking funding amounts to specific and measurable energy improvements;
- Providing building owners with clear, reliable, and actionable information, making renovations more accessible.

Future studies on BRP should consider enhancing data accessibility across the building life cycle to meet the specific needs of various stakeholders (Buchholz & Lützkendorf, 2023). A promising path for this is the integration of BPR with virtual building models, such as Building Information Modelling (BIM) and digital twins, which can serve as comprehensive data sources throughout the life cycle of a building. Traditionally, BIM has primarily been employed in the design phase. Still, it is increasingly recognised as a valuable tool beyond this phase, offering insights and applications that span construction, maintenance, and renovation. Linking BPR to a digital logbook, incorporating BIM or digital twin data, could improve data continuity and usability.

7. CONCLUSIONS

The final chapter summarises the main subjects covered and developed throughout the dissertation. It offers a synopsis of the most relevant considerations, even though some important conclusions have already been emphasised throughout the work.

7.1 Conclusions

Worldwide, people are facing the challenge of climate change and the need to accelerate the global transition to clean energy to achieve net zero emissions by 2050 at the latest. The solution involves integrating measures to adapt to climate change with actions to reduce or avoid greenhouse gas emissions in ways that provide broader benefits.

The role of buildings in addressing today's most pressing challenges cannot be overstated. As a critical sector for environmental sustainability and social well-being, the decarbonisation of building stock represents a necessary step towards meeting climate goals and a significant opportunity to drive transformative societal change and improve the quality of life for millions. The built environment is at the heart of the global effort to combat climate change, reduce emissions, and ensure social equity, especially in rising energy poverty.

In recent years, the urgency of decarbonising the building sector has spurred significant advancements in research and the development of tools to achieve a just transition. The concept of a "just transition" emphasises that environmental progress must not come at the expense of the most vulnerable members of society. Addressing energy poverty — a critical issue disproportionately affecting low-income households — is central to this mission. EU policies, particularly the Renovation Wave initiative, are at the forefront of addressing energy poverty while driving the deep renovation of Europe's ageing building stock. The Renovation Wave aims to ensure that energy efficiency measures lower emissions and alleviate the financial burdens on vulnerable citizens.

The EPBD's recast emphasises the need to implement effective measures for carrying out extensive renovations in the existing building stock across the EU. This legislative push is vital for enhancing the built environment's sustainability and affordability. Deep renovation measures are crucial for achieving significant energy savings and improving living conditions, especially for those experiencing energy poverty.

EPCs and BRPs play a pivotal role in this process. As informational tools, they provide homeowners and tenants with essential insights into their renovation needs and help predict the outcomes of energy efficiency measures. When linked with One-Stop shops, EPCs and BRPs can facilitate access to tailored advice and financing options, making renovation processes more accessible, especially for financially constrained households. This integrated approach is crucial for ensuring that all citizens, regardless of income, can participate in the transition to a more energy-efficient and climate-resilient future.

Access to financial support is a critical component of this transition. Vulnerable citizens, who are often most affected by rising energy costs, need robust financial mechanisms to ensure they can afford the necessary home upgrades. By linking EPCs and BRPs to funding schemes and other financial instruments, the EU and member states can ensure that the deep renovation of homes is not just a possibility for the affluent but an achievable goal for all.

However, achieving these goals requires more than technological or financial solutions. Empowering citizens is essential to reaching climate goals and ensuring equitable transition. Citizens must be actively engaged in the process and equipped with the knowledge and resources to make informed decisions about their energy consumption, renovation options, and long-term investments in sustainability. This empowerment is central to creating people-centred cities prioritising affordability and environmental responsibility.

The question arises of how to use BRP to assist vulnerable households in recognising their energy needs, developing decision-making capacity regarding their living conditions, and addressing the underlying injustices related to energy poverty and inequality.

This study confirmed that BRPs can provide personalised renovation roadmaps outlining specific energy efficiency measures tailored to each household's unique circumstances, facilitating and supporting deep renovations for low-income households. This can help vulnerable households better understand their energy needs by presenting a clear picture of their home's current energy performance and the potential benefits of targeted renovations, such as reduced energy bills and improved comfort.

Results show that by providing accessible, step-by-step renovation plans, BRPs empower households to make informed decisions about energy improvements. They simplify complex technical information, making it easier for occupants to prioritise renovations, identify necessary upgrades, and understand their long-term benefits. This transparency helps build confidence among vulnerable households navigating the renovation process and investing in energy-saving measures.

BRP can be integrated with financial schemes and incentives, connecting vulnerable households to funding opportunities such as subsidies, grants, or low-interest loans. This reduces the financial barriers to renovation, enabling low-income households to access the necessary resources to improve their living conditions. Linking BRPs to One-Stop shops further enhances this by providing expert advice and assistance navigating financial options.

7.2 Future Work

The research revealed that BRPs can address the systemic issues of energy poverty and inequality by prioritising renovations that directly impact the most vulnerable households. By targeting improvements that reduce energy costs, enhance health outcomes, and increase comfort, BRPs help to address the broader social injustices associated with inadequate housing and energy insecurity.

This study did not address how BRPs can provide guidance and foster long-term empowerment by educating households on sustainable energy practices. Identifying potential energy savings and environmental benefits could encourage households to proactively manage their energy consumption, thus reducing dependency on external aid and contributing to greater energy autonomy.

Aligning building use with affordability and climate goals is crucial for addressing energy poverty and creating sustainable, low-carbon cities. Empowering citizens and providing them with tools, knowledge, and financial support can help build environmentally sustainable and inclusive cities. As the world moves towards ambitious climate targets, buildings will continue to play a crucial role in reducing emissions and enhancing citizens' quality of life. The transition to energy-efficient buildings is not just a technical challenge but a moral imperative to ensure that no one is left behind in the fight against climate change.

However, further research is needed to expand this study into related areas to fully explore BRPs' potential in addressing energy efficiency and renovation needs. One challenge is that BRPs remain a voluntary tool. As a result, many property owners may overlook energy efficiency measures, opting instead for superficial upgrades or cosmetic renovations that do not improve the building's long-term performance.

The revised EPBD, in Annex VIII, introduces new requirements for BRPs. These include providing information on potential connections to efficient district heating and cooling systems and general guidance on improving the circularity of construction materials and reducing whole-life-cycle greenhouse gas emissions.

These requirements have not yet been subjected to extensive case studies or in-depth research. While the potential benefits of integrating these new elements into BRPs are promising, their practical application and

effectiveness remain underexplored, particularly in diverse contexts such as low-income or energy-poor households. Rigorous case studies and empirical research are necessary to assess how these requirements function in real-world scenarios and to ensure that they can effectively address the needs of different building owners, especially the most vulnerable.

There remains a significant gap in research on applying renovation roadmaps, or BRPs, to low-income or energy-poor households. While this tool has demonstrated potential in guiding property owners through energy efficiency improvements, there is limited understanding of how they can be tailored to vulnerable populations' specific needs and financial constraints. More research is needed to explore how renovation roadmaps can be effectively adapted to support low-income households in overcoming the barriers to energy-efficient renovations, particularly in the context of energy poverty.

These updates reinforce the role of BRPs as a tool for energy efficiency and for promoting sustainable, resilient, and health-focused renovations, encouraging a more holistic approach to building improvements.

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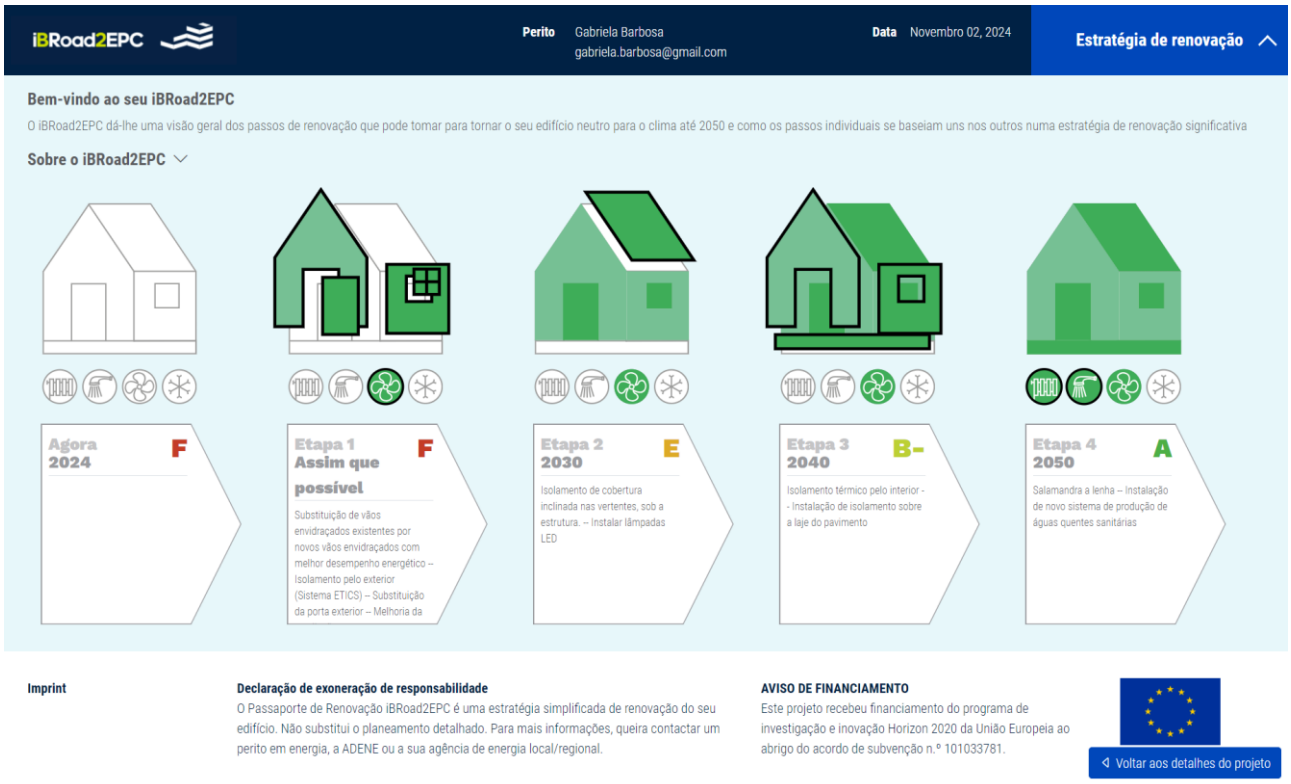
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ANNEX 1- iBRoad2EPC- House nº 1



iBRoad2EPC

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Data Novembro 02, 2024

Etapa 1

Etapa 1 — Assim que possível

Medida 1

Substituição de vãos envidraçados existentes por novos vãos envidraçados com melhor desempenho energético

Descrição da ação

Substituição de todas as janelas que tenham mais de 10 anos. Se substituir as janelas, colocando ou não isolamento nas paredes exteriores, peça a um especialista para avaliar possíveis pontes térmicas e risco relacionados de condensações/fungos. Pergunte também se a ventilação mínima continua a ser assegurada. As novas janelas devem ser ligadas à alvenaria de forma hermética com soluções de longa duração. Espumar com espuma de instalação não é normalmente suficiente.

Especificação da medida

UW = 2,80 W/(m²K)

Preparativos para medidas de renovação posteriores

Quando as janelas ou portas estiverem a ser substituídas, por favor prepare-se para o posterior isolamento das paredes pelo interior, concebendo as pontes térmicas e as ligações à padieira, ombreira ou peitoril para o para o período de transição até ao isolamento das paredes. A impermeabilidade ao ar, a proteção térmica mínima e a proteção contra a humidade devem ser asseguradas a todo o momento.

Quando as janelas ou portas no rés-do-chão estiverem a ser substituídas, preparar para um isolamento posterior do pavimento pelo interior. As alturas da padieira, ombreira ou peitoril devem ser alinhadas com a altura futura do pavimento.

Quando as janelas ou portas estão a ser substituídas, os ajustes de controlo do sistema existente devem ser adaptados à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas de fluxo e o caudal da bomba do circuito de aquecimento podem ser reduzidos.



Medida 2

Isolamento pelo exterior (Sistema ETICS)

Descrição da ação

Isolamento de toda a parede exterior pelo exterior através de um sistema ETICS (External Thermal Insulation Composite Systems). Os componentes do ETICS, tais como cimento, placas de isolamento, blindagem e gesso, são ajustados uns aos outros e juntos formam um sistema certificado. Espuma de poliestireno, fibra mineral ou materiais de isolamento renováveis são normalmente utilizados como isolamento.

Especificação da medida

U = 0,35 W/(m²K) ou 10 cm de espessura

Preparativos para medidas de renovação posteriores

Quando a parede exterior estiver a ser isolada, os set points do sistema de aquecimento existente devem ser adaptados à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas e o caudal da bomba do circuito podem ser reduzidos.

Quando as paredes exteriores estão a ser isoladas, pode preparar uma futura centralização do fornecimento de água quente instalando as tubagens necessárias atrás da camada de isolamento da parede e conduzindo-os de volta ao interior; isto poupará esforços redundantes no futuro e evitará instalações dispendiosas no interior. A conversão para um sistema central de AQS pode ser implementada numa fase posterior, quando o sistema de produção de calor for substituído.



Medida 3

Substituição da porta exterior

Descrição da ação

Substituição das portas exteriores por portas com baixo coeficiente de transmissão térmico.

Especificação da medida

U = 1,20 W/(m²K)

Preparativos para medidas de renovação posteriores

Quando as janelas ou portas estiverem a ser substituídas, por favor prepare-se para o posterior isolamento das paredes pelo interior, concebendo as pontes térmicas e as ligações à padieira, ombreira ou peitoril para o para o período de transição até ao isolamento das paredes. A impermeabilidade ao ar, a proteção térmica mínima e a proteção contra a humidade devem ser asseguradas a todo o momento.

Quando as janelas ou portas no rés-do-chão estiverem a ser substituídas, preparar para um isolamento posterior do pavimento pelo interior. As alturas da padieira, ombreira ou peitoril devem ser alinhadas com a altura futura do pavimento.

Quando as janelas ou portas estão a ser substituídas, as definições de controlo do gerador de calor existente devem ser adaptadas à previsível menor necessidade de energia útil. O seu instalador deve verificar se as temperaturas de fluxo e o caudal da bomba do circuito de aquecimento podem ser reduzidos.



Medida 4

Melhoria da ventilação

Descrição da ação

Especialmente durante a estação de arrefecimento, as condições de conforto térmico são otimizadas pelas possibilidades de ventilação natural no interior dos edifícios. Portanto, a ventilação cruzada (janelas em lados opostos) ou a ventilação passiva (ventilação de telhado e janelas) podem ser utilizadas para para aumentar a ventilação natural nos espaços dos edifícios.

Especificação da medida

Grelhas autoregulaveis + ventax na I.S.



Voltar

Imprint

Declaração de exoneração de responsabilidade
O Passaporte de Renovação iBRoad2EPC é uma estratégia simplificada de renovação do seu edifício. Não substitui o planeamento detalhado. Para mais informações, queira contactar um perito em energia, a ADENE ou a sua agência de energia local/regional.

AVISO DE FINANCIAMENTO
Este projeto recebeu financiamento do programa de investigação e inovação Horizon 2020 da União Europeia ao abrigo do acordo de subvenção n.º 101033781.

iBRoad2EPC

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Data Novembro 02, 2024

Etapa 2

Etapa 2 **2030**

Objectivos ou regulamentos obrigatórios

Até 1 de Janeiro de 2030, 65% dos edifícios residenciais deverão ter substituído toda a iluminação por LED e terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Até 1 de Janeiro de 2030, 23% dos edifícios residenciais que não atinjam níveis da categoria III de conforto após a introdução de medidas passivas deverão dispor de sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas. Os sistemas de GPL deverão ter sido substituídos com prioridade para as famílias que vivem em situação de pobreza energética.

Até 1 de Janeiro de 2030, 50% das necessidades de aquecimento de água para edifícios residenciais terão de ser asseguradas por sistemas solares térmicos (cerca de 23% do parque habitacional deverá estar equipado com estes sistemas)

Até 1 de Janeiro de 2030, os edifícios construídos antes de 1990 deverão atingir pelo menos a categoria III de conforto através da introdução de medidas passivas na envolvente (isolamento, janelas eficientes, etc.).

Medida 1

Isolamento de cobertura inclinada nas vertentes, sob a estrutura.

Descrição da ação

Isolamento de cobertura inclinada nas vertentes. O trabalho é realizado a partir do interior. As telhas não têm de ser substituídas durante o trabalho. Dependendo da estrutura da construção do telhado, o revestimento das inclinações do telhado pode ser mantido. Por baixo das vigas, são colocadas ripas de madeira adicionais. A sua altura determina a espessura do isolamento. Podem ser instaladas verticalmente, horizontalmente ou como contra ripas. O material de isolamento pode ser de fibra mineral, espuma de poliestireno ou materiais renováveis e é instalado sem folgas entre as ripas e fixado contra quedas. Como regra, a camada de isolamento do lado da sala é protegida com uma membrana de barreira de vapor. Esta pode servir como uma camada hermética. Neste caso, todas as juntas devem ser herméticas com fita adesiva. Não deve ser cortada demasiado curta nos bordos para que possa ser ligada à alvenaria de forma segura e permanente. Recomenda-se verificar a estanqueidade ao ar através de testes antes de instalar o revestimento interior.

Especificação da medida

U = 0,35 W/(m²K) ou 10 cm de espessura

Preparativos para medidas de renovação posteriores

Quando a cobertura estiver a ser isolada, as definições de controlo do sistema de aquecimento existente devem ser adaptadas à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas e o caudal da bomba do circuito podem ser reduzidos.



Medida 2

Instalar lâmpadas LED

Descrição da ação

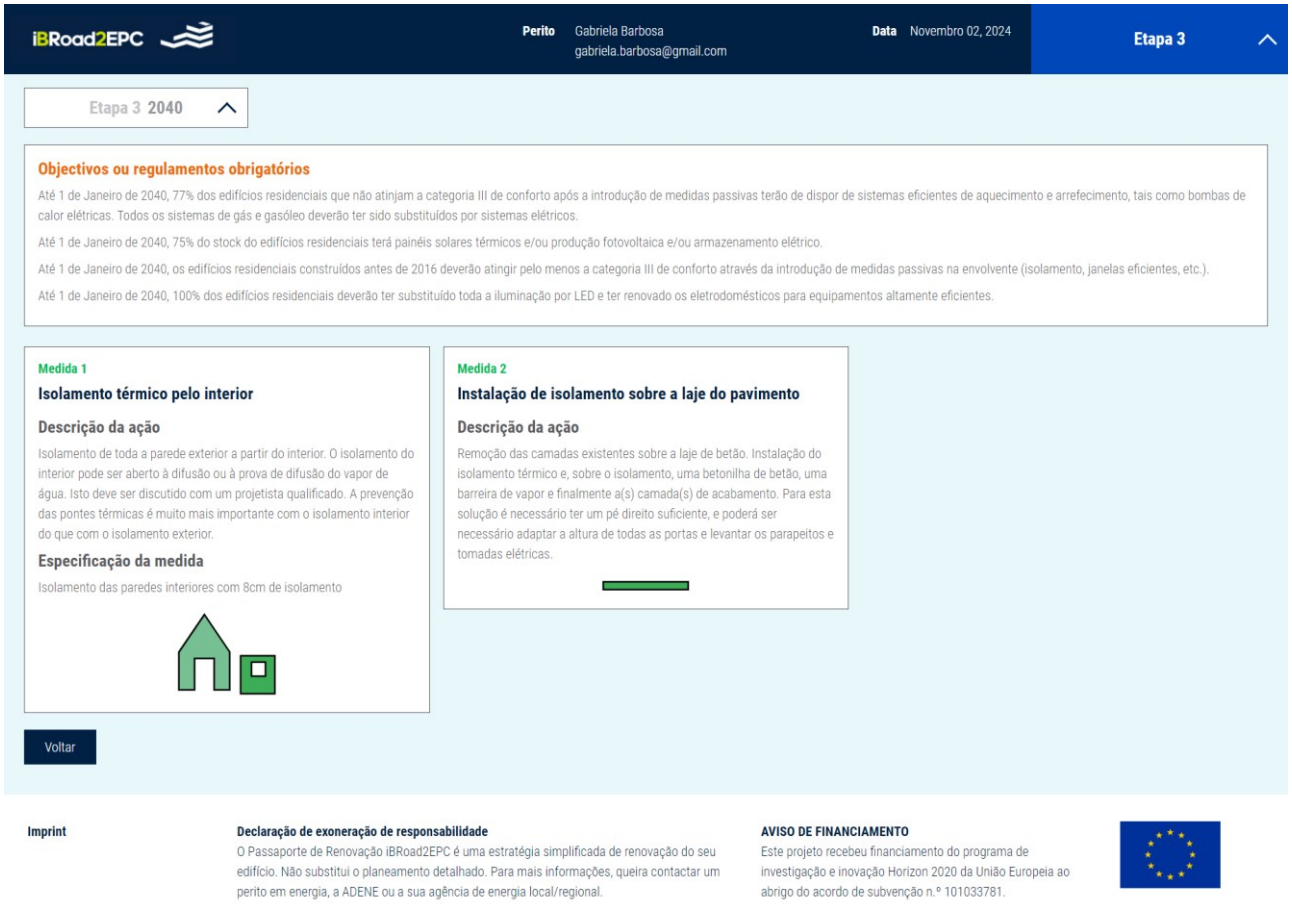
Remoção das velhas lâmpadas e instalação de novas lâmpadas LED. Estas podem poupar até 90 % do consumo de energia em comparação com as lâmpadas mais antigas. Opte por fabricantes de qualidade que garantam uma durabilidade de 10 anos ou mais.

Voltar

Imprint

Declaração de exoneração de responsabilidade
O Passaporte de Renovação iBRoad2EPC é uma estratégia simplificada de renovação do seu edifício. Não substitui o planeamento detalhado. Para mais informações, queira contactar um perito em energia, a ADENE ou a sua agência de energia local/regional.

AVISO DE FINANCIAMENTO
Este projeto recebeu financiamento do programa de investigação e inovação Horizon 2020 da União Europeia ao abrigo do acordo de subvenção n.º 101033781.


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Data Novembro 02, 2024
Etapa 3
Etapa 3 2040
Objectivos ou regulamentos obrigatórios
Até 1 de Janeiro de 2040, 77% dos edifícios residenciais que não atinjam a categoria III de conforto após a introdução de medidas passivas terão de dispor de sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas. Todos os sistemas de gás e gasóleo deverão ter sido substituídos por sistemas elétricos.
Até 1 de Janeiro de 2040, 75% do stock do edifícios residenciais terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.
Até 1 de Janeiro de 2040, os edifícios residenciais construídos antes de 2016 deverão atingir pelo menos a categoria III de conforto através da introdução de medidas passivas na envolvente (isolamento, janelas eficientes, etc.).
Até 1 de Janeiro de 2040, 100% dos edifícios residenciais deverão ter substituído toda a iluminação por LED e ter renovado os eletrodomésticos para equipamentos altamente eficientes.
Medida 1
Isolamento térmico pelo interior
Descrição da ação
Isolamento de toda a parede exterior a partir do interior. O isolamento do interior pode ser aberto à difusão ou à prova de difusão do vapor de água. Isto deve ser discutido com um projetista qualificado. A prevenção das pontes térmicas é muito mais importante com o isolamento interior do que com o isolamento exterior.
Especificação da medida
Isolamento das paredes interiores com 8cm de isolamento
Medida 2
Instalação de isolamento sobre a laje do pavimento
Descrição da ação
Remoção das camadas existentes sobre a laje de betão. Instalação do isolamento térmico e, sobre o isolamento, uma betonilha de betão, uma barreira de vapor e finalmente a(s) camada(s) de acabamento. Para esta solução é necessário ter um pé direito suficiente, e poderá ser necessário adaptar a altura de todas as portas e levantar os parapeitos e tomadas elétricas.
Voltar
Imprint
Declaração de exoneração de responsabilidade
O Passaporte de Renovação iBRoad2EPC é uma estratégia simplificada de renovação do seu edifício. Não substitui o planeamento detalhado. Para mais informações, queira contactar um perito em energia, a ADENE ou a sua agência de energia local/regional.
AVISO DE FINANCIAMENTO
Este projeto recebeu financiamento do programa de investigação e inovação Horizon 2020 da União Europeia ao abrigo do acordo de subvenção n.º 101033781.

iBRoad2EPC

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Data Novembro 02, 2024

Etapa 4

Etapa 4 **2050**

Objectivos ou regulamentos obrigatórios

Até 1 de Janeiro de 2050, 100% dos edifícios residenciais que não atinjam a categoria III de conforto após a introdução de medidas passivas deverão ter instalados sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas.

Até 1 de Janeiro de 2050, 100% do stock de edifícios residenciais terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Medida 1

Salamandra a lenha

Descrição da ação

Instalação e montagem de uma salamandra a lenha. É operado independentemente de outros geradores de calor. Certifique-se de que a salamadra cumpre os requisitos de protecção contra emissões e de protecção contra incêndios. Assegurar-se de que existe um abastecimento suficiente de ar de combustão.

Especificação da medida

A potência deve ser dimensionada para o seu edifício. Salamandra a pellets

Medida 2

Instalação de novo sistema de produção de águas quentes sanitárias

Descrição da ação

Numa caldeira de água quente doméstica, a água potável é aquecida directamente com electricidade ou gás. Existem diferentes tipos de caldeiras. Exemplos são os esquentadores, depósitos de água quente aquecida directa ou indirectamente, sistemas solares térmicos, caldeiras de biomassa ou bombas de calor. Substitua a sua antiga caldeira de água por uma nova e eficiente.

Especificação da medida

Bomba de calor

Voltar

Imprint

Declaração de exoneração de responsabilidade
O Passaporte de Renovação iBRoad2EPC é uma estratégia simplificada de renovação do seu edifício. Não substitui o planeamento detalhado. Para mais informações, queira contactar um perito em energia, a ADENE ou a sua agência de energia local/regional.

AVISO DE FINANCIAMENTO
Este projeto recebeu financiamento do programa de investigação e inovação Horizon 2020 da União Europeia ao abrigo do acordo de subvenção n.º 101033781.

iBRoad2EPC

Perito Gabriela Barbosa
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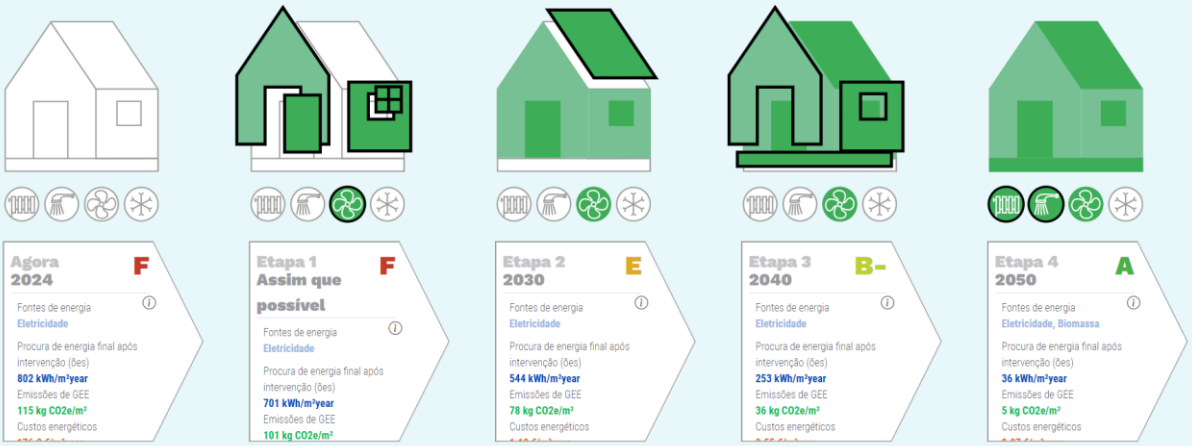
Data Novembro 02, 2024

Energia

Sobre a procura de energia

Este resumo mostra-lhe a fonte de energia, a procura final de energia, as emissões de gases com efeito de estufa e os custos de energia em cada etapa de renovação. Desta forma, o iBRoad2EPC mostra o impacto das medidas de renovação sobre o consumo de energia do seu edifício.

Informação adicional

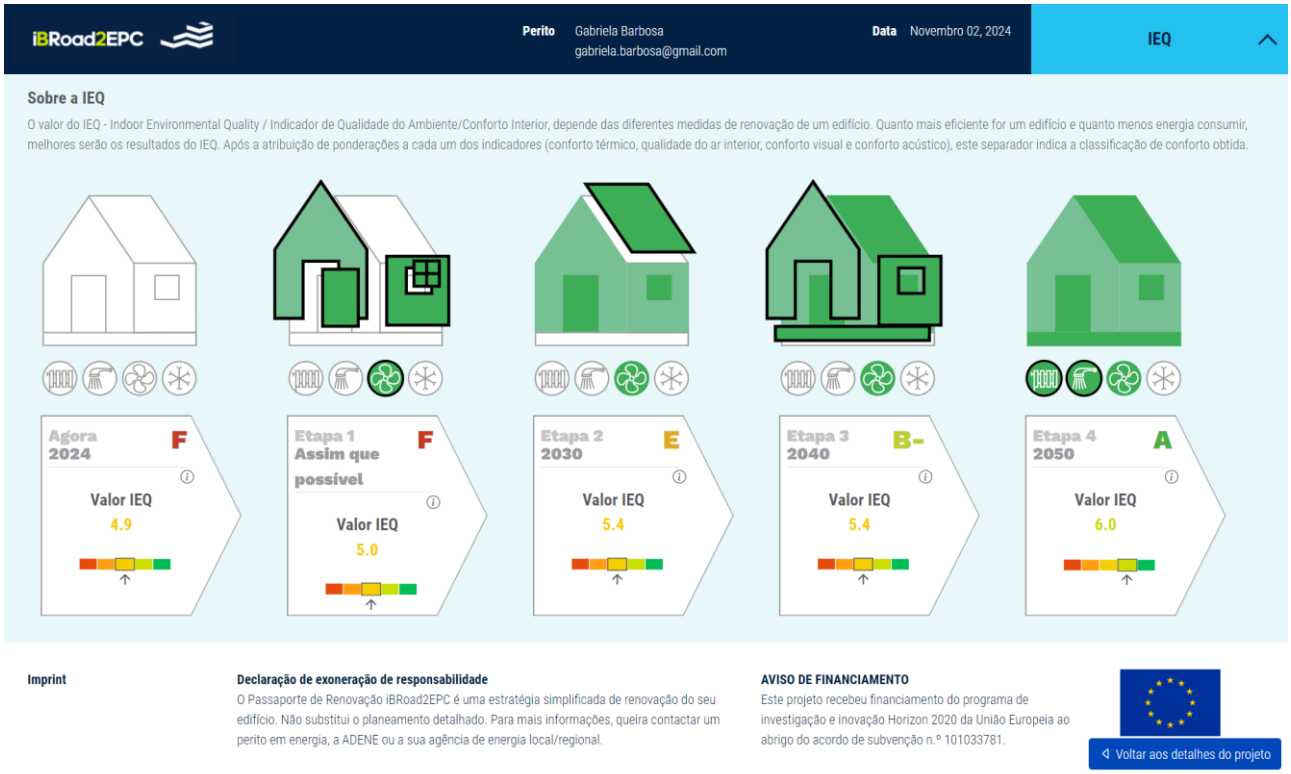


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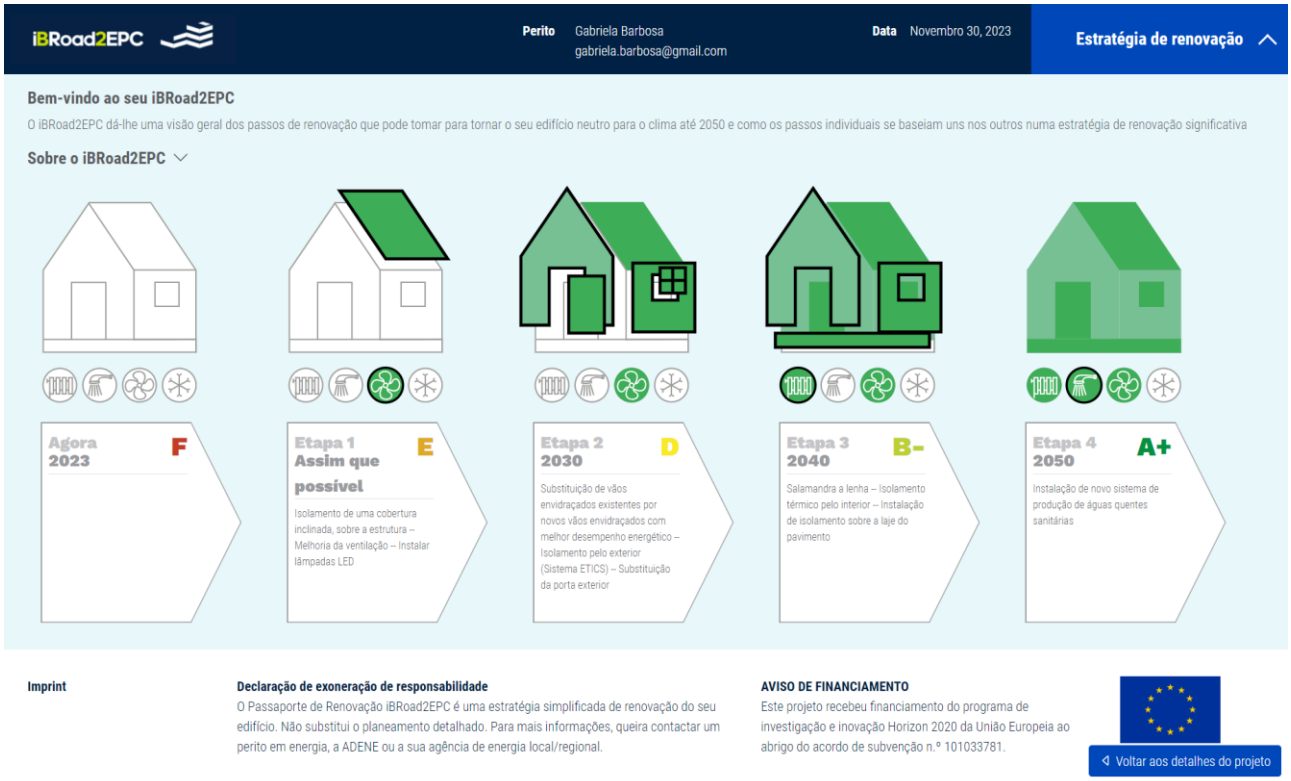
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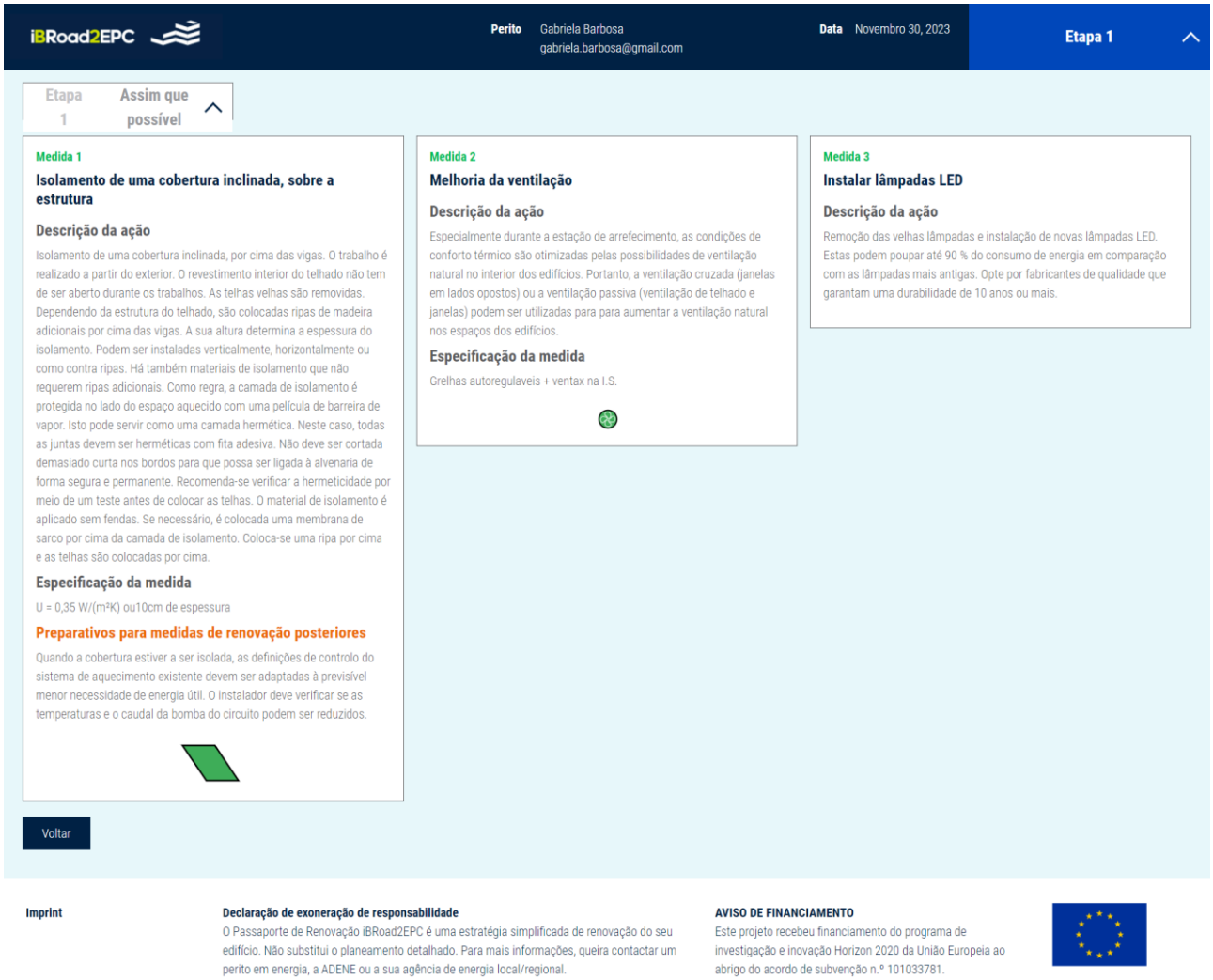
AVISO DE FINANCIAMENTO
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Voltar aos detalhes do projeto


iBRoad2EPC
Perito Gabriela Barbosa
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Data Novembro 02, 2024
IEQ
Sobre a IEQ
O valor do IEQ - Indoor Environmental Quality / Indicador de Qualidade do Ambiente/Conforto Interior, depende das diferentes medidas de renovação de um edifício. Quanto mais eficiente for um edifício e quanto menos energia consumir, melhores serão os resultados do IEQ. Após a atribuição de ponderações a cada um dos indicadores (conforto térmico, qualidade do ar interior, conforto visual e conforto acústico), este separador indica a classificação de conforto obtida.
Agora 2024
F
Valor IEQ
4.9
Etapa 1
Assim que possível
F
Valor IEQ
5.0
Etapa 2
2030
E
Valor IEQ
5.4
Etapa 3
2040
B-
Valor IEQ
5.4
Etapa 4
2050
A
Valor IEQ
6.0
Imprint
Declaração de exoneração de responsabilidade
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Voltar aos detalhes do projeto

ANNEX II – iBRoad2EPC – House n° 3





Imprint

Declaração de exoneração de responsabilidade
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iBRoad2EPC

Perito Gabriela Barbosa
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Data Novembro 30, 2023

Etapa 2

Etapa 2 **2030**

Objectivos ou regulamentos obrigatórios

Até 1 de Janeiro de 2030, 65% dos edifícios residenciais deverão ter substituído toda a iluminação por LED e terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Até 1 de Janeiro de 2030, 23% dos edifícios residenciais que não atinjam níveis da categoria III de conforto após a introdução de medidas passivas deverão dispor de sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas. Os sistemas de GPL deverão ter sido substituídos com prioridade para as famílias que vivem em situação de pobreza energética.

Até 1 de Janeiro de 2030, os edifícios construídos antes de 1990 deverão atingir pelo menos a categoria III de conforto através da introdução de medidas passivas na envolvente (isolamento, janelas eficientes, etc.).

Até 1 de Janeiro de 2030, 50% das necessidades de aquecimento de água para edifícios residenciais terão de ser asseguradas por sistemas solares térmicos (cerca de 23% do parque habitacional deverá estar equipado com estes sistemas)

Medida 1

Substituição de vãos envidraçados existentes por novos vãos envidraçados com melhor desempenho energético

Descrição da ação

Substituição de todas as janelas que tenham mais de 10 anos. Se substituir as janelas, colocando ou não isolamento nas paredes exteriores, peça a um especialista para avaliar possíveis pontes térmicas e risco relacionados de condensações/fungos. Pergunte também se a ventilação mínima continua a ser assegurada. As novas janelas devem ser ligadas à alvenaria de forma hermética com soluções de longa duração. Espumar com espuma de instalação não é normalmente suficiente.

Especificação da medida

UW = 2,80 W/(m²K)

Preparativos para medidas de renovação posteriores

Quando as janelas ou portas estiverem a ser substituídas, por favor prepare-se para o posterior isolamento das paredes pelo interior, concebendo as pontes térmicas e as ligações à padieira, ombreira ou peitoril para o para o período de transição até ao isolamento das paredes. A impermeabilidade ao ar, a proteção térmica mínima e a proteção contra a humidade devem ser asseguradas a todo o momento.

Quando as janelas ou portas no rés-do-chão estiverem a ser substituídas, preparar para um isolamento posterior do pavimento pelo interior. As alturas da padieira, ombreira ou peitoril devem ser alinhadas com a altura futura do pavimento.

Quando as janelas ou portas estão a ser substituídas, os ajustes de controlo do sistema existente devem ser adaptados à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas de fluxo e o caudal da bomba do circuito de aquecimento podem ser reduzidos.

Medida 2

Isolamento pelo exterior (Sistema ETICS)

Descrição da ação

Isolamento de toda a parede exterior pelo exterior através de um sistema ETICS (External Thermal Insulation Composite Systems). Os componentes do ETICS, tais como cimento, placas de isolamento, blindagem e gesso, são ajustados uns aos outros e juntos formam um sistema certificado. Espuma de poliestireno, fibra mineral ou materiais de isolamento renováveis são normalmente utilizados como isolamento.

Especificação da medida

U = 0,35 W/(m²K) ou 10cm de espessura

Preparativos para medidas de renovação posteriores

Quando as paredes exteriores estão a ser isoladas, pode preparar uma futura centralização do fornecimento de água quente instalando as tubagens necessárias atrás da camada de isolamento da parede e conduzindo-os de volta ao interior; isto poupará esforços redundantes no futuro e evitará instalações dispendiosas no interior. A conversão para um sistema central de AQS pode ser implementada numa fase posterior, quando o sistema de produção de calor for substituído.

Quando a parede exterior estiver a ser isolada, os set points do sistema de aquecimento existente devem ser adaptados à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas e o caudal da bomba do circuito podem ser reduzidos.



Medida 3

Substituição da porta exterior

Descrição da ação

Substituição das portas exteriores por portas com baixo coeficiente de transmissão térmico.

Especificação da medida

U = 1,20 W/(m²K)

Preparativos para medidas de renovação posteriores

Quando as janelas ou portas estiverem a ser substituídas, por favor prepare-se para o posterior isolamento das paredes pelo interior, concebendo as pontes térmicas e as ligações à padieira, ombreira ou peitoril para o para o período de transição até ao isolamento das paredes. A impermeabilidade ao ar, a proteção térmica mínima e a proteção contra a humidade devem ser asseguradas a todo o momento.

Quando as janelas ou portas no rés-do-chão estiverem a ser substituídas, preparar para um isolamento posterior do pavimento pelo interior. As alturas da padieira, ombreira ou peitoril devem ser alinhadas com a altura futura do pavimento.

Quando as janelas ou portas estão a ser substituídas, as definições de controlo do gerador de calor existente devem ser adaptadas à previsível menor necessidade de energia útil. O seu instalador deve verificar se as temperaturas de fluxo e o caudal da bomba do circuito de aquecimento podem ser reduzidos.

Voltar

Imprint

Declaração de exoneração de responsabilidade
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iBRoad2EPC

Perito Gabriela Barbosa
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Data Novembro 30, 2023

Etapa 3

Etapa 3 **2040**

Objectivos ou regulamentos obrigatórios

Até 1 de Janeiro de 2040, 77% dos edifícios residenciais que não atinjam a categoria III de conforto após a introdução de medidas passivas terão de dispor de sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas. Todos os sistemas de gás e gasóleo deverão ter sido substituídos por sistemas elétricos.

Até 1 de Janeiro de 2040, 75% do stock do edifícios residenciais terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Até 1 de Janeiro de 2040, os edifícios residenciais construídos antes de 2016 deverão atingir pelo menos a categoria III de conforto através da introdução de medidas passivas na envolvente (isolamento, janelas eficientes, etc.).

Até 1 de Janeiro de 2040, 100% dos edifícios residenciais deverão ter substituído toda a iluminação por LED e ter renovado os eletrodomésticos para equipamentos altamente eficientes.

Medida 1

Salamandra a lenha

Descrição da ação

Instalação e montagem de uma salamandra a lenha. É operado independentemente de outros geradores de calor. Certifique-se de que a salamadra cumpre os requisitos de protecção contra emissões e de protecção contra incêndios. Assegurar-se de que existe um abastecimento suficiente de ar de combustão.

Especificação da medida

A potência deve ser dimensionada para o seu edifício.

Preparativos para medidas de renovação posteriores

Ao substituir o sistema de aquecimento, deve preparar-se para um posterior isolamento das paredes exteriores, selecionando uma capacidade de aquecimento que seja ajustada ao edifício já isolado numa etapa posterior. Isto permitir-lhe-á comprar um sistema mais pequeno e mais barato o que irá aumentar a sua eficiência após a medida de isolamento.

Medida 2

Isolamento térmico pelo interior

Descrição da ação

Isolamento de toda a parede exterior a partir do interior. O isolamento do interior pode ser aberto à difusão ou à prova de difusão do vapor de água. Isto deve ser discutido com um projetista qualificado. A prevenção das pontes térmicas é muito mais importante com o isolamento interior do que com o isolamento exterior.

Especificação da medida

Isolamento das paredes interiores com 8cm de isolamento



Medida 3

Instalação de isolamento sobre a laje do pavimento

Descrição da ação

Remoção das camadas existentes sobre a laje de betão. Instalação do isolamento térmico e, sobre o isolamento, uma betonilha de betão, uma barreira de vapor e finalmente a(s) camada(s) de acabamento. Para esta solução é necessário ter um pé direito suficiente, e poderá ser necessário adaptar a altura de todas as portas e levantar os parapeitos e tomadas elétricas.

Voltar

Imprint

Declaração de exoneração de responsabilidade

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AVISO DE FINANCIAMENTO

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iBRoad2EPC

Perito Gabriela Barbosa
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Data Novembro 30, 2023

Etapa 4

Etapa 4 **2050**

Objectivos ou regulamentos obrigatórios

Até 1 de Janeiro de 2050, 100% dos edifícios residenciais que não atinjam a categoria III de conforto após a introdução de medidas passivas deverão ter instalados sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas.

Até 1 de Janeiro de 2050, 100% do stock de edifícios residenciais terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Medida 1

Instalação de novo sistema de produção de águas quentes sanitárias

Descrição da ação

Numa caldeira de água quente doméstica, a água potável é aquecida directamente com electricidade ou gás. Existem diferentes tipos de caldeiras. Exemplos são os esquentadores, depósitos de água quente aquecida directa ou indirectamente, sistemas solares térmicos, caldeiras de biomassa ou bombas de calor. Substitua a sua antiga caldeira de água por uma nova e eficiente.

Especificação da medida

Bomba de calor

Voltar

Imprint

Declaração de exoneração de responsabilidade
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iBRoad2EPC

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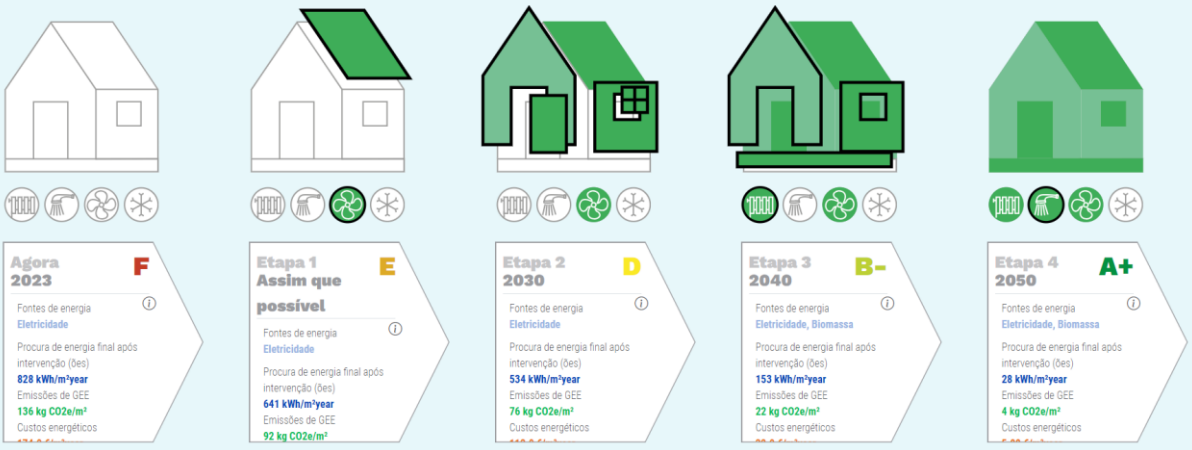
Data Novembro 30, 2023

Energia

Sobre a procura de energia

Este resumo mostra-lhe a fonte de energia, a procura final de energia, as emissões de gases com efeito de estufa e os custos de energia em cada etapa de renovação. Desta forma, o iBRoad2EPC mostra o impacto das medidas de renovação sobre o consumo de energia do seu edifício.

Informação adicional

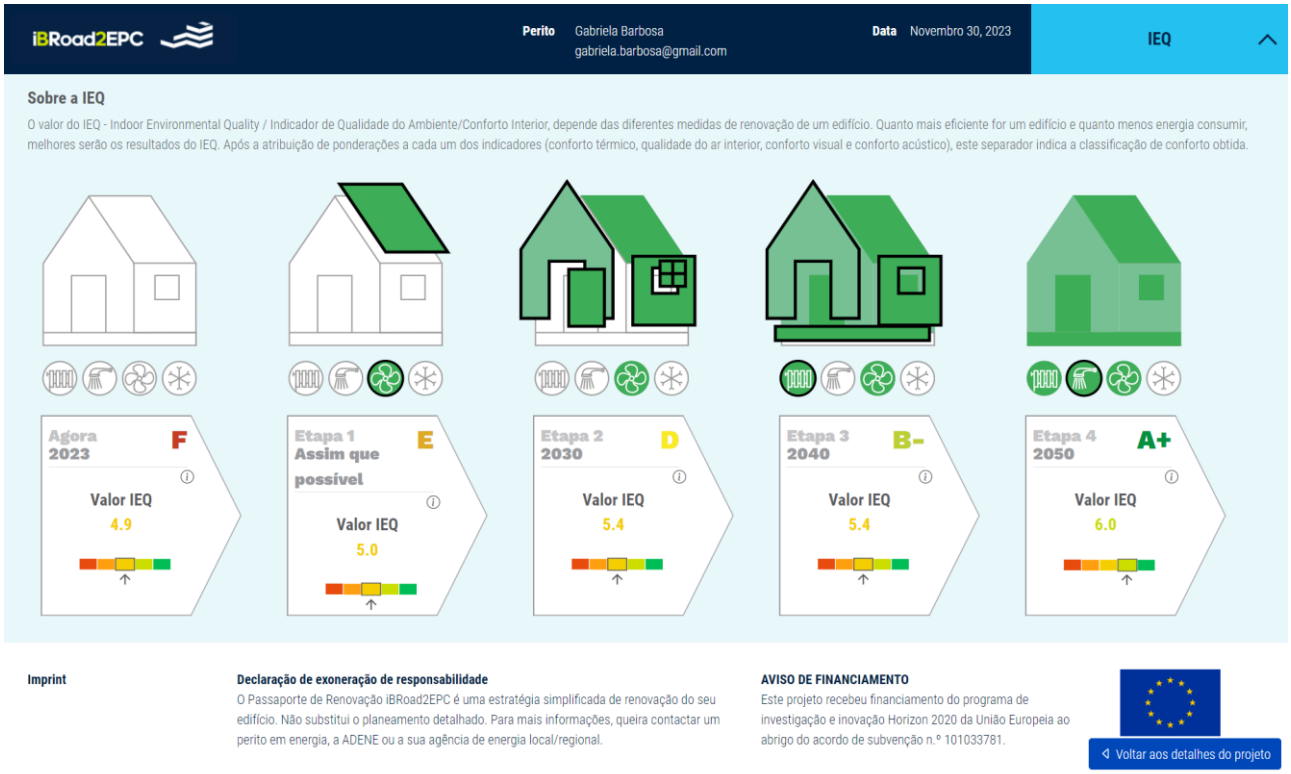


Imprint

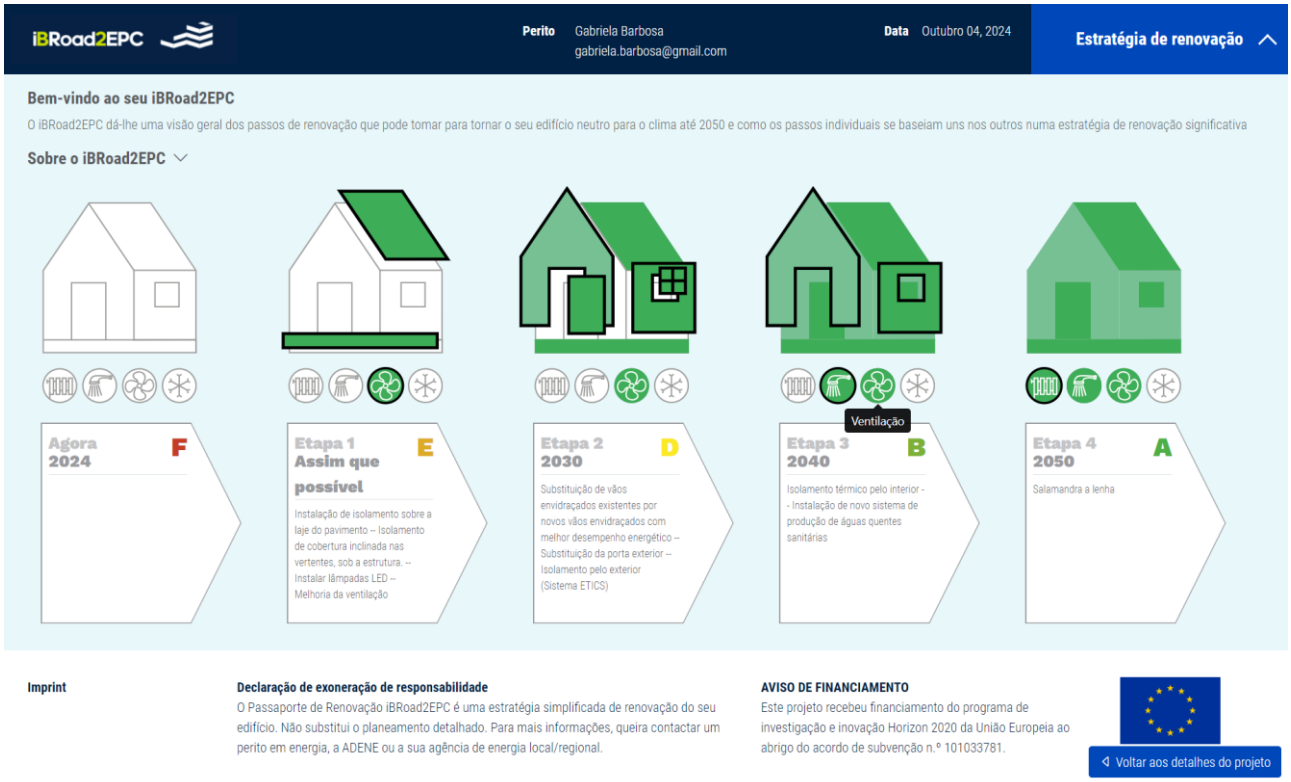
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Voltar aos detalhes do projeto



ANNEX III- iBRoad2EPC- House n° 5



iBRoad2EPC

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Data Outubro 04, 2024

Etapa 1

Etapa 1 — Assim que possível

Medida 1

Instalação de isolamento sobre a laje do pavimento

Descrição da ação

Remoção das camadas existentes sobre a laje de betão. Instalação do isolamento térmico e, sobre o isolamento, uma betonilha de betão, uma barreira de vapor e finalmente a(s) camada(s) de acabamento. Para esta solução é necessário ter um pé direito suficiente, e poderá ser necessário adaptar a altura de todas as portas e levantar os parapeitos e tomadas elétricas.

Medida 2

Isolamento de cobertura inclinada nas vertentes, sob a estrutura.

Descrição da ação

Isolamento de cobertura inclinada nas vertentes. O trabalho é realizado a partir do interior. As telhas não têm de ser substituídas durante o trabalho. Dependendo da estrutura da construção do telhado, o revestimento das inclinações do telhado pode ser mantido. Por baixo das vigas, são colocadas ripas de madeira adicionais. A sua altura determina a espessura do isolamento. Podem ser instaladas verticalmente, horizontalmente ou como contra ripas. O material de isolamento pode ser de fibra mineral, espuma de poliestireno ou materiais renováveis e é instalado sem folgas entre as ripas e fixado contra quedas. Como regra, a camada de isolamento do lado da sala é protegida com uma membrana de barreira de vapor. Esta pode servir como uma camada hermética. Neste caso, todas as juntas devem ser herméticas com fita adesiva. Não deve ser cortada demasiado curta nos bordos para que possa ser ligada à alvenaria de forma segura e permanente. Recomenda-se verificar a estanqueidade ao ar através de testes antes de instalar o revestimento interior.

Especificação da medida

U = 0,35 W/(m²K) ou 10 cm de espessura

Preparativos para medidas de renovação posteriores

Quando a cobertura estiver a ser isolada, as definições de controlo do sistema de aquecimento existente devem ser adaptadas à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas e o caudal da bomba do circuito podem ser reduzidos.

Medida 3

Instalar lâmpadas LED

Descrição da ação

Remoção das velhas lâmpadas e instalação de novas lâmpadas LED. Estas podem poupar até 90 % do consumo de energia em comparação com as lâmpadas mais antigas. Opte por fabricantes de qualidade que garantam uma durabilidade de 10 anos ou mais.

Medida 4

Melhoria da ventilação

Descrição da ação

Especialmente durante a estação de arrefecimento, as condições de conforto térmico são otimizadas pelas possibilidades de ventilação natural no interior dos edifícios. Portanto, a ventilação cruzada (janelas em lados opostos) ou a ventilação passiva (ventilação de telhado e janelas) podem ser utilizadas para para aumentar a ventilação natural nos espaços dos edifícios.

Especificação da medida

Grelhas autoregulaveis + ventax na I.S.

Voltar

Imprint

Declaração de exoneração de responsabilidade
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iBRoad2EPC

Perito Gabriela Barbosa
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Data Outubro 04, 2024

Etapa 2

Etapa 2 **2030**

Objectives ou regulamentos obrigatórios

Até 1 de Janeiro de 2030, 65% dos edifícios residenciais deverão ter substituído toda a iluminação por LED e terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Até 1 de Janeiro de 2030, 23% dos edifícios residenciais que não atinjam níveis da categoria III de conforto após a introdução de medidas passivas deverão dispor de sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas. Os sistemas de GPL deverão ter sido substituídos com prioridade para as famílias que vivem em situação de pobreza energética.

Até 1 de Janeiro de 2030, 50% das necessidades de aquecimento de água para edifícios residenciais terão de ser asseguradas por sistemas solares térmicos (cerca de 23% do parque habitacional deverá estar equipado com estes sistemas)

Até 1 de Janeiro de 2030, os edifícios construídos antes de 1990 deverão atingir pelo menos a categoria III de conforto através da introdução de medidas passivas na envolvente (isolamento, janelas eficientes, etc.).

Medida 1

Substituição de vãos envidraçados existentes por novos vãos envidraçados com melhor desempenho energético

Descrição da ação

Substituição de todas as janelas que tenham mais de 10 anos. Se substituir as janelas, colocando ou não isolamento nas paredes exteriores, peça a um especialista para avaliar possíveis pontes térmicas e risco relacionados de condensações/fungos. Pergunte também se a ventilação mínima continua a ser assegurada. As novas janelas devem ser ligadas à alvenaria de forma hermética com soluções de longa duração. Espumar com espuma de instalação não é normalmente suficiente.

Especificação da medida

UW = 2,80 W/(m²K)

Preparativos para medidas de renovação posteriores

Quando as janelas ou portas estiverem a ser substituídas, por favor prepare-se para o posterior isolamento das paredes pelo interior, concebendo as pontes térmicas e as ligações à padieira, ombreira ou peitoril para o para o período de transição até ao isolamento das paredes. A impermeabilidade ao ar, a proteção térmica mínima e a proteção contra a humidade devem ser asseguradas a todo o momento.

Quando as janelas ou portas estão a ser substituídas, os ajustes de controlo do sistema existente devem ser adaptados à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas de fluxo e o caudal da bomba do circuito de aquecimento podem ser reduzidos.



Medida 2

Substituição da porta exterior

Descrição da ação

Substituição das portas exteriores por portas com baixo coeficiente de transmissão térmico.

Especificação da medida

U = 1,20 W/(m²K)

Preparativos para medidas de renovação posteriores

Quando as janelas ou portas estiverem a ser substituídas, por favor prepare-se para o posterior isolamento das paredes pelo interior, concebendo as pontes térmicas e as ligações à padieira, ombreira ou peitoril para o para o período de transição até ao isolamento das paredes. A impermeabilidade ao ar, a proteção térmica mínima e a proteção contra a humidade devem ser asseguradas a todo o momento.

Quando as janelas ou portas estão a ser substituídas, as definições de controlo do gerador de calor existente devem ser adaptadas à previsível menor necessidade de energia útil. O seu instalador deve verificar se as temperaturas de fluxo e o caudal da bomba do circuito de aquecimento podem ser reduzidos.



Medida 3

Isolamento pelo exterior (Sistema ETICS)

Descrição da ação

Isolamento de toda a parede exterior pelo exterior através de um sistema ETICS (External Thermal Insulation Composite Systems). Os componentes do ETICS, tais como cimento, placas de isolamento, blindagem e gesso, são ajustados uns aos outros e juntos formam um sistema certificado. Espuma de poliestireno, fibra mineral ou materiais de isolamento renováveis são normalmente utilizados como isolamento.

Especificação da medida

U = 0,35W/(m²K) ou 10 cm de espessura

Preparativos para medidas de renovação posteriores

Quando as paredes exteriores estão a ser isoladas, pode preparar uma futura centralização do fornecimento de água quente instalando as tubagens necessárias atrás da camada de isolamento da parede e conduzindo-os de volta ao interior; isto poupará esforços redundantes no futuro e evitará instalações dispendiosas no interior. A conversão para um sistema central de AQS pode ser implementada numa fase posterior, quando o sistema de produção de calor for substituído.

Quando a parede exterior estiver a ser isolada, os set points do sistema de aquecimento existente devem ser adaptados à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas e o caudal da bomba do circuito podem ser reduzidos.



Voltar

Imprint

Declaração de exoneração de responsabilidade
O Passaporte de Renovação iBRoad2EPC é uma estratégia simplificada de renovação do seu edifício. Não substitui o planeamento detalhado. Para mais informações, queira contactar um perito em energia, a ADENE ou a sua agência de energia local/regional.

AVISO DE FINANCIAMENTO
Este projeto recebeu financiamento do programa de investigação e inovação Horizon 2020 da União Europeia ao abrigo do acordo de subvenção n.º 101033781.

iBRoad2EPC

Perito Gabriela Barbosa
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Data Outubro 04, 2024

Etapa 3

Etapa 3 2040

Objectivos ou regulamentos obrigatórios

Até 1 de Janeiro de 2040, 77% dos edifícios residenciais que não atinjam a categoria III de conforto após a introdução de medidas passivas terão de dispor de sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas. Todos os sistemas de gás e gasóleo deverão ter sido substituídos por sistemas elétricos.

Até 1 de Janeiro de 2040, 75% do stock do edifícios residenciais terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Até 1 de Janeiro de 2040, os edifícios residenciais construídos antes de 2016 deverão atingir pelo menos a categoria III de conforto através da introdução de medidas passivas na envolvente (isolamento, janelas eficientes, etc.).

Até 1 de Janeiro de 2040, 100% dos edifícios residenciais deverão ter substituído toda a iluminação por LED e ter renovado os eletrodomésticos para equipamentos altamente eficientes.

Medida 1

Isolamento térmico pelo interior

Descrição da ação

Isolamento de toda a parede exterior a partir do interior. O isolamento do interior pode ser aberto à difusão ou à prova de difusão do vapor de água. Isto deve ser discutido com um projetista qualificado. A prevenção das pontes térmicas é muito mais importante com o isolamento interior do que com o isolamento exterior.

Especificação da medida

Isolamento das paredes interiores com 8cm de isolamento



Medida 2

Instalação de novo sistema de produção de águas quentes sanitárias

Descrição da ação

Numa caldeira de água quente doméstica, a água potável é aquecida directamente com electricidade ou gás. Existem diferentes tipos de caldeiras. Exemplos são os esquentadores, depósitos de água quente aquecida directa ou indirectamente, sistemas solares térmicos, caldeiras de biomassa ou bombas de calor. Substitua a sua antiga caldeira de água por uma nova e eficiente.

Especificação da medida

Bomba de calor

Voltar

Imprint

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iBRoad2EPC

Perito Gabriela Barbosa
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Data Outubro 04, 2024

Etapa 4

Etapa 4 2050

Objectivos ou regulamentos obrigatórios

Até 1 de Janeiro de 2050, 100% dos edifícios residenciais que não atinjam a categoria III de conforto após a introdução de medidas passivas deverão ter instalados sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas.

Até 1 de Janeiro de 2050, 100% do stock de edifícios residenciais terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Medida 1

Salamandra a lenha

Descrição da ação

Instalação e montagem de uma salamandra a lenha. É operado independentemente de outros geradores de calor. Certifique-se de que a salamadra cumpre os requisitos de protecção contra emissões e de protecção contra incêndios. Assegurar-se de que existe um abastecimento suficiente de ar de combustão.

Especificação da medida

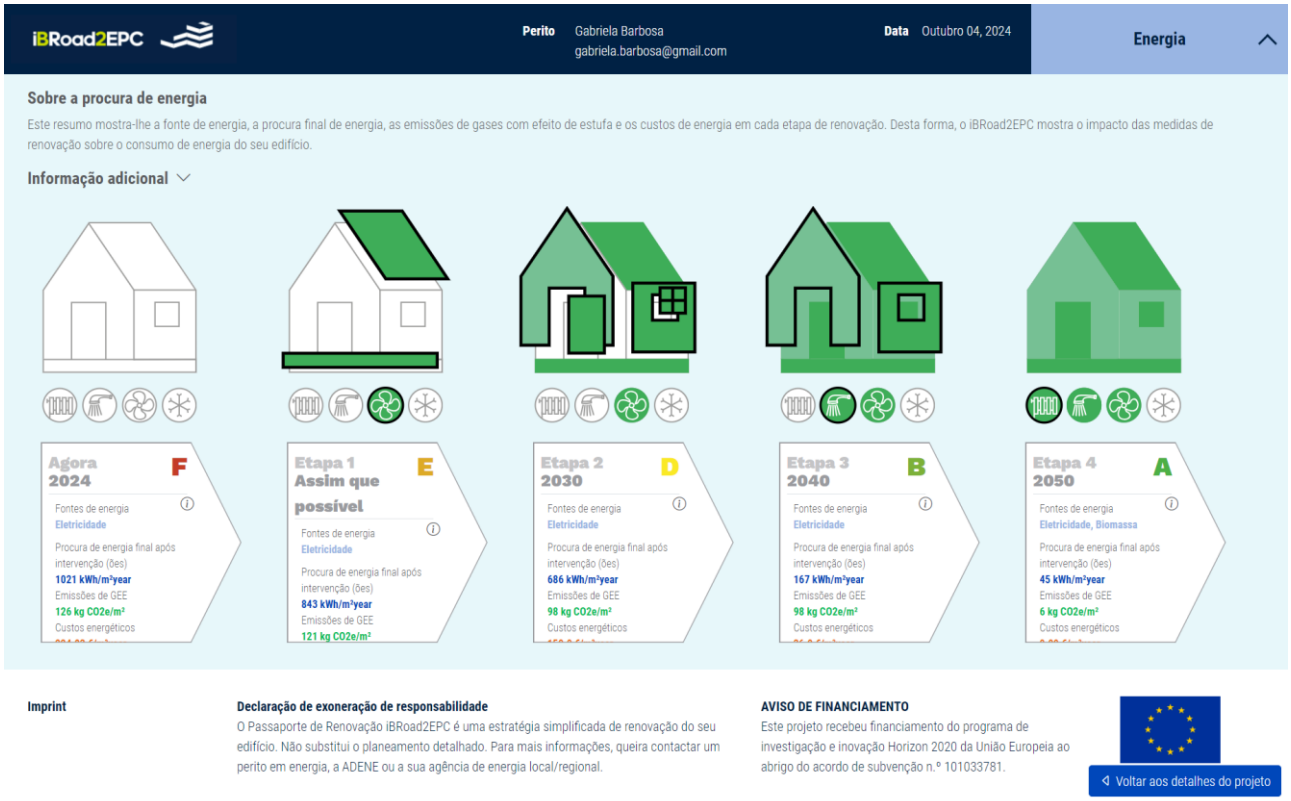
A potência deve ser dimensionada para o seu edifício. Salamandra a pellets

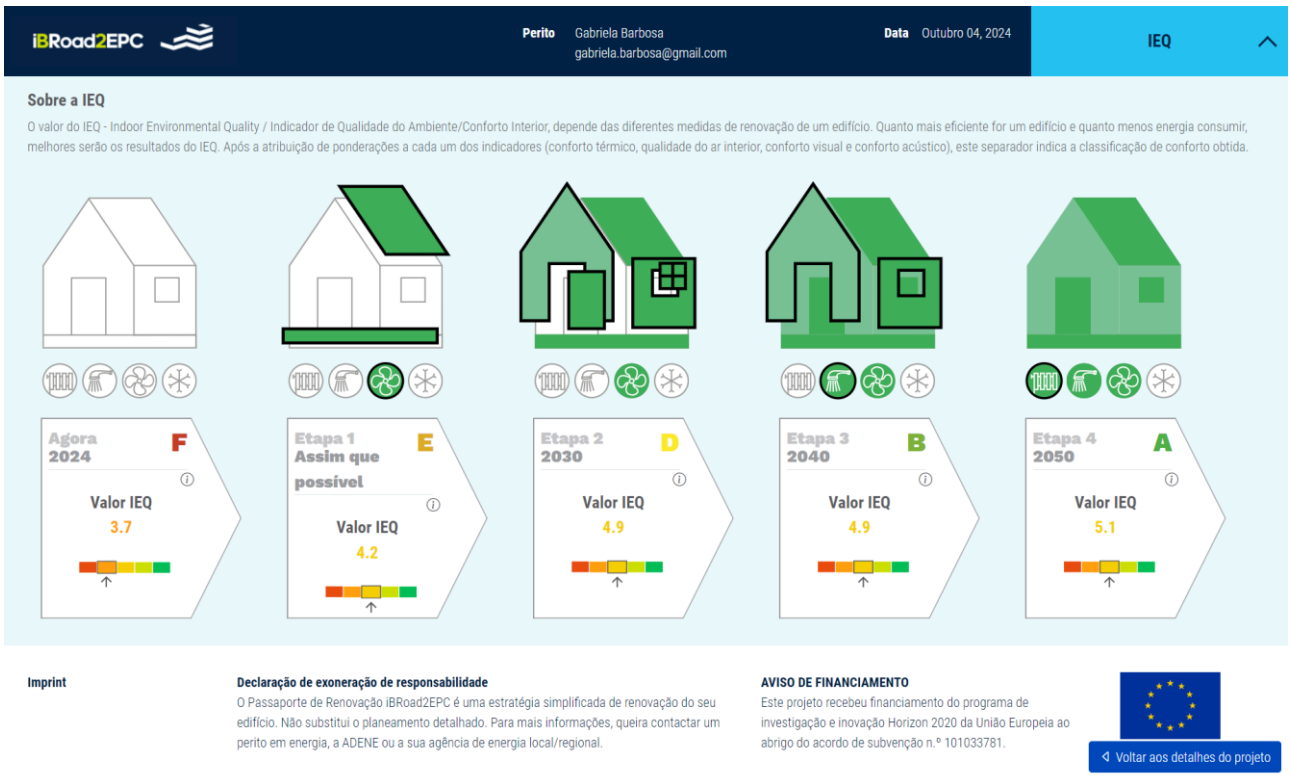
Voltar

Imprint

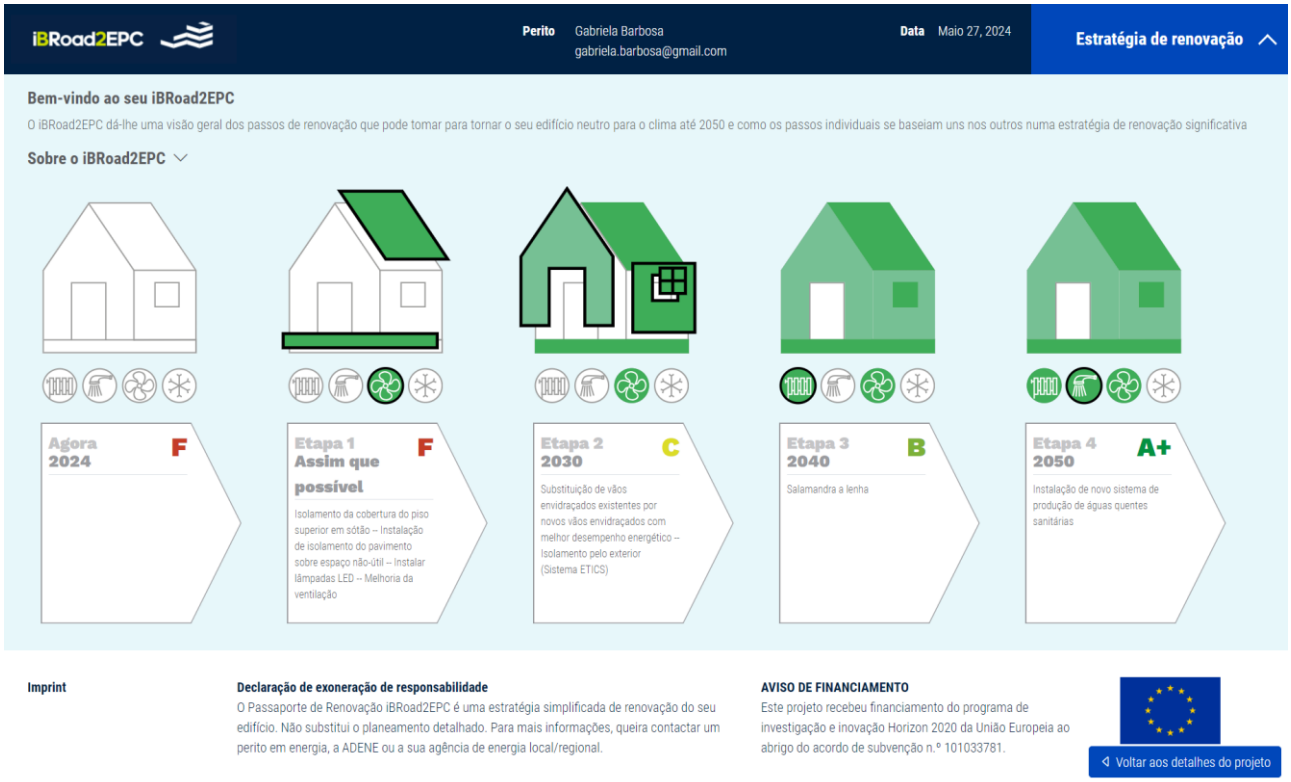
Declaração de exoneração de responsabilidade
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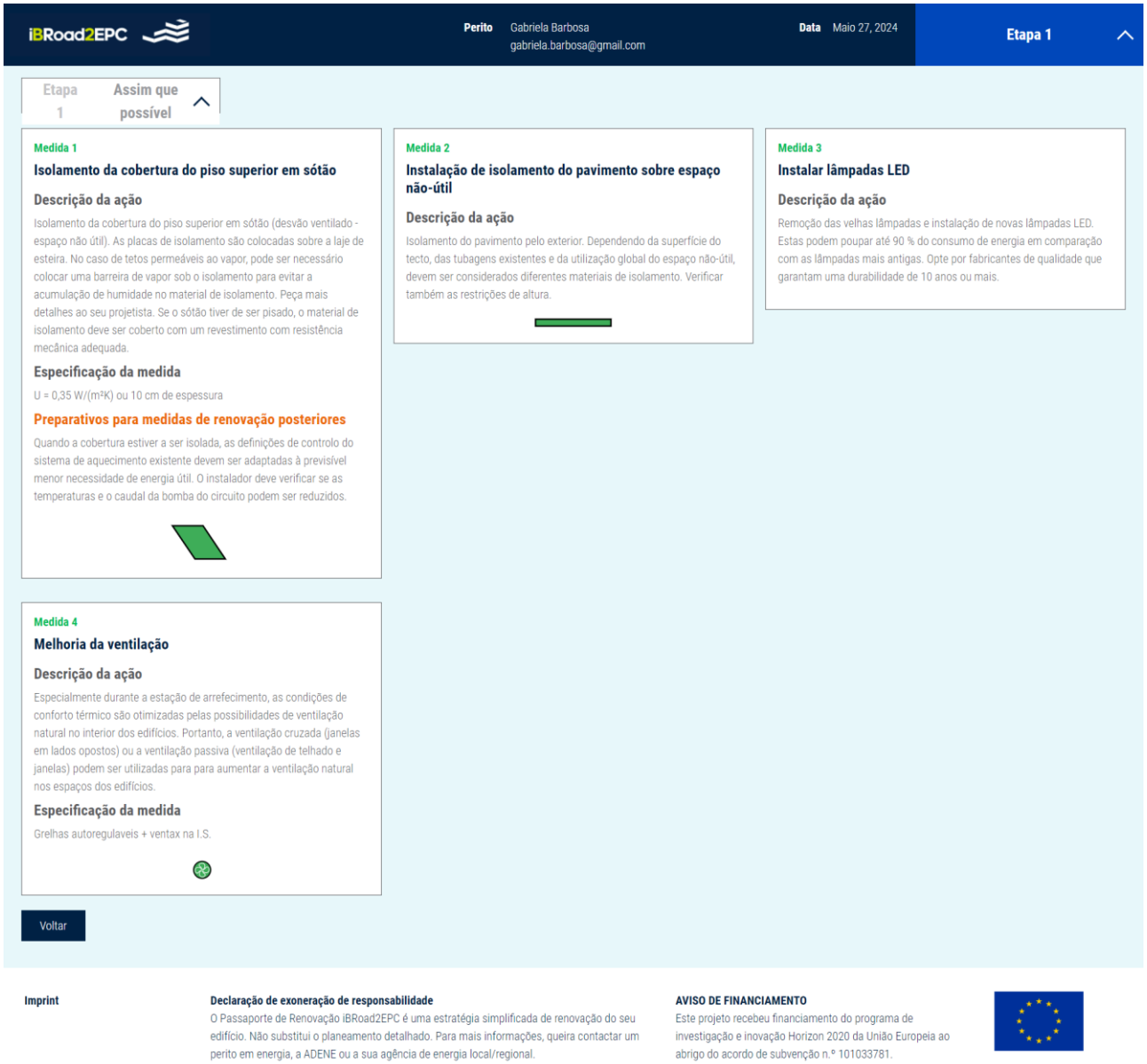
AVISO DE FINANCIAMENTO
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iBRoad2EPC
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Data Outubro 04, 2024
Energia
Sobre a procura de energia
Este resumo mostra-lhe a fonte de energia, a procura final de energia, as emissões de gases com efeito de estufa e os custos de energia em cada etapa de renovação. Desta forma, o iBRoad2EPC mostra o impacto das medidas de renovação sobre o consumo de energia do seu edifício.
Informação adicional
Agora 2024 F
Fontes de energia
Eletricidade
Procura de energia final após intervenção (0es)
1021 kWh/m²year
Emissões de GEE
126 kg CO2e/m²
Custos energéticos
Etapa 1 Assim que possível E
Fontes de energia
Eletricidade
Procura de energia final após intervenção (0es)
843 kWh/m²year
Emissões de GEE
121 kg CO2e/m²
Etapa 2 2030 D
Fontes de energia
Eletricidade
Procura de energia final após intervenção (0es)
686 kWh/m²year
Emissões de GEE
98 kg CO2e/m²
Custos energéticos
Etapa 3 2040 B
Fontes de energia
Eletricidade
Procura de energia final após intervenção (0es)
167 kWh/m²year
Emissões de GEE
98 kg CO2e/m²
Custos energéticos
Etapa 4 2050 A
Fontes de energia
Eletricidade, Biomassa
Procura de energia final após intervenção (0es)
45 kWh/m²year
Emissões de GEE
6 kg CO2e/m²
Custos energéticos
Imprint
Declaração de exoneração de responsabilidade
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Voltar aos detalhes do projeto


iBRoad2EPC
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Data Outubro 04, 2024
IEQ
Sobre a IEQ
O valor do IEQ - Indoor Environmental Quality / Indicador de Qualidade do Ambiente/Conforto Interior, depende das diferentes medidas de renovação de um edifício. Quanto mais eficiente for um edifício e quanto menos energia consumir, melhores serão os resultados do IEQ. Após a atribuição de ponderações a cada um dos indicadores (conforto térmico, qualidade do ar interior, conforto visual e conforto acústico), este separador indica a classificação de conforto obtida.
Agora 2024 F
Valor IEQ
3.7
Etapa 1 Assim que possível E
Valor IEQ
4.2
Etapa 2 2030 D
Valor IEQ
4.9
Etapa 3 2040 B
Valor IEQ
4.9
Etapa 4 2050 A
Valor IEQ
5.1
Imprint
Declaração de exoneração de responsabilidade
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AVISO DE FINANCIAMENTO
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Voltar aos detalhes do projeto

ANNEX IV- iBRoad2EPC- House n° 13




iBRoad2EPC
Perito Gabriela Barbosa
gabriela.barbosa@gmail.com
Data Maio 27, 2024
Etapa 1
Etapa 1
Assim que possível
Medida 1
Isolamento da cobertura do piso superior em sótão
Descrição da ação
Isolamento da cobertura do piso superior em sótão (desvão ventilado - espaço não útil). As placas de isolamento são colocadas sobre a laje de esteira. No caso de tetos permeáveis ao vapor, pode ser necessário colocar uma barreira de vapor sob o isolamento para evitar a acumulação de humidade no material de isolamento. Peça mais detalhes ao seu projetista. Se o sótão tiver de ser pisado, o material de isolamento deve ser coberto com um revestimento com resistência mecânica adequada.
Especificação da medida
U = 0,35 W/(m²K) ou 10 cm de espessura
Preparativos para medidas de renovação posteriores
Quando a cobertura estiver a ser isolada, as definições de controlo do sistema de aquecimento existente devem ser adaptadas à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas e o caudal da bomba do circuito podem ser reduzidos.
Medida 2
Instalação de isolamento do pavimento sobre espaço não-útil
Descrição da ação
Isolamento do pavimento pelo exterior. Dependendo da superfície do tecto, das tubagens existentes e da utilização global do espaço não-útil, devem ser considerados diferentes materiais de isolamento. Verificar também as restrições de altura.
Medida 3
Instalar lâmpadas LED
Descrição da ação
Remoção das velhas lâmpadas e instalação de novas lâmpadas LED. Estas podem poupar até 90 % do consumo de energia em comparação com as lâmpadas mais antigas. Opte por fabricantes de qualidade que garantam uma durabilidade de 10 anos ou mais.
Medida 4
Melhoria da ventilação
Descrição da ação
Especialmente durante a estação de arrefecimento, as condições de conforto térmico são otimizadas pelas possibilidades de ventilação natural no interior dos edifícios. Portanto, a ventilação cruzada (janelas em lados opostos) ou a ventilação passiva (ventilação de telhado e janelas) podem ser utilizadas para para aumentar a ventilação natural nos espaços dos edifícios.
Especificação da medida
Grelhas autoregulaveis + ventax na I.S.
Voltar
Imprint
Declaração de exoneração de responsabilidade
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iBRoad2EPC

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Data Maio 27, 2024

Etapa 2

Etapa 2 **2030**

Objectivos ou regulamentos obrigatórios

Até 1 de Janeiro de 2030, 65% dos edifícios residenciais deverão ter substituído toda a iluminação por LED e terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.

Até 1 de Janeiro de 2030, 23% dos edifícios residenciais que não atinjam níveis da categoria III de conforto após a introdução de medidas passivas deverão dispor de sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas. Os sistemas de GPL deverão ter sido substituídos com prioridade para as famílias que vivem em situação de pobreza energética.

Até 1 de Janeiro de 2030, os edifícios construídos antes de 1990 deverão atingir pelo menos a categoria III de conforto através da introdução de medidas passivas na envolvente (isolamento, janelas eficientes, etc.).

Até 1 de Janeiro de 2030, 50% das necessidades de aquecimento de água para edifícios residenciais terão de ser asseguradas por sistemas solares térmicos (cerca de 23% do parque habitacional deverá estar equipado com estes sistemas)

Medida 1

Substituição de vãos envidraçados existentes por novos vãos envidraçados com melhor desempenho energético

Descrição da ação

Substituição de todas as janelas que tenham mais de 10 anos. Se substituir as janelas, colocando ou não isolamento nas paredes exteriores, peça a um especialista para avaliar possíveis pontes térmicas e risco relacionados de condensações/fungos. Pergunte também se a ventilação mínima continua a ser assegurada. As novas janelas devem ser ligadas à alvenaria de forma hermética com soluções de longa duração. Espumar com espuma de instalação não é normalmente suficiente.

Especificação da medida

UW = 2,80 W/(m²K)

Preparativos para medidas de renovação posteriores

Quando as janelas ou portas estão a ser substituídas, os ajustes de controlo do sistema existente devem ser adaptados à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas de fluxo e o caudal da bomba do circuito de aquecimento podem ser reduzidos.



Medida 2

Isolamento pelo exterior (Sistema ETICS)

Descrição da ação

Isolamento de toda a parede exterior pelo exterior através de um sistema ETICS (External Thermal Insulation Composite Systems). Os componentes do ETICS, tais como cimento, placas de isolamento, blindagem e gesso, são ajustados uns aos outros e juntos formam um sistema certificado. Espuma de poliestireno, fibra mineral ou materiais de isolamento renováveis são normalmente utilizados como isolamento.

Especificação da medida

U = 0,35 W/(m²K) ou 10 cm de espessura

Preparativos para medidas de renovação posteriores

Quando as paredes exteriores estão a ser isoladas, pode preparar uma futura centralização do fornecimento de água quente instalando as tubagens necessárias atrás da camada de isolamento da parede e conduzindo-os de volta ao interior; isto poupará esforços redundantes no futuro e evitará instalações dispendiosas no interior. A conversão para um sistema central de AQS pode ser implementada numa fase posterior, quando o sistema de produção de calor for substituído.

Quando a parede exterior estiver a ser isolada, os set points do sistema de aquecimento existente devem ser adaptados à previsível menor necessidade de energia útil. O instalador deve verificar se as temperaturas e o caudal da bomba do circuito podem ser reduzidos.

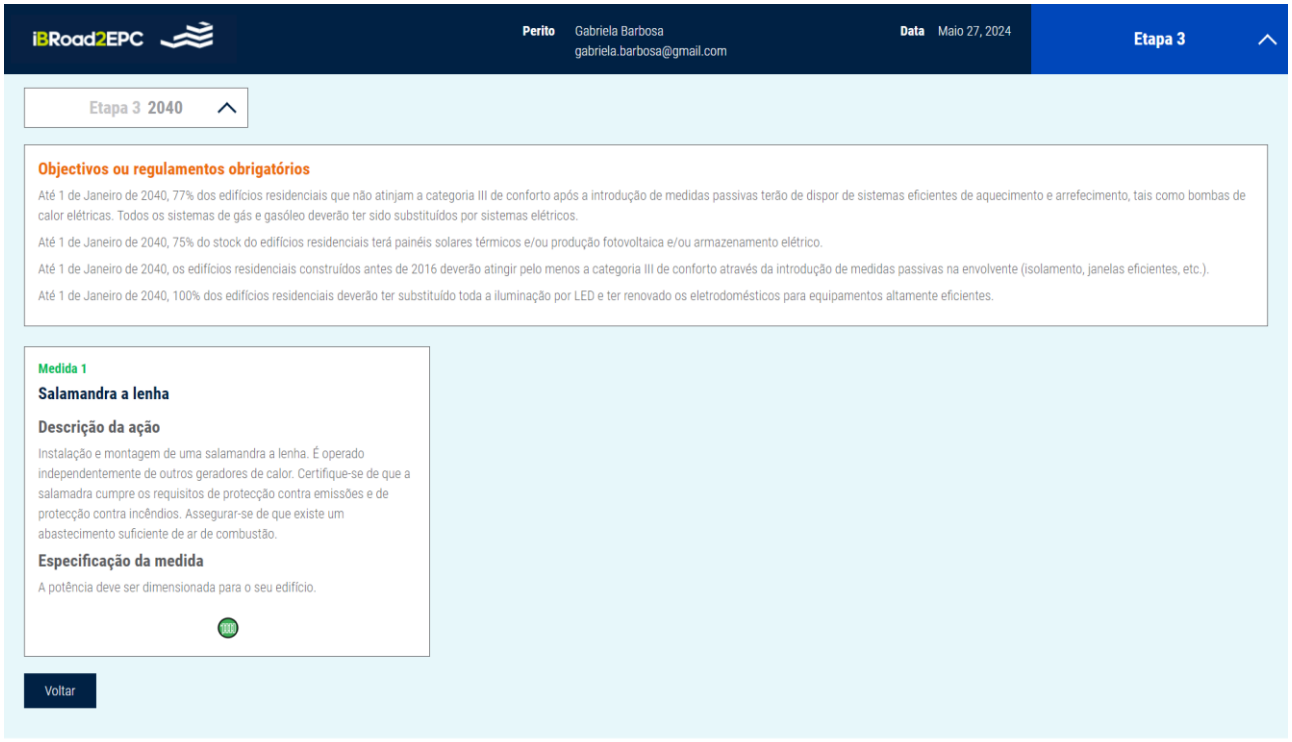


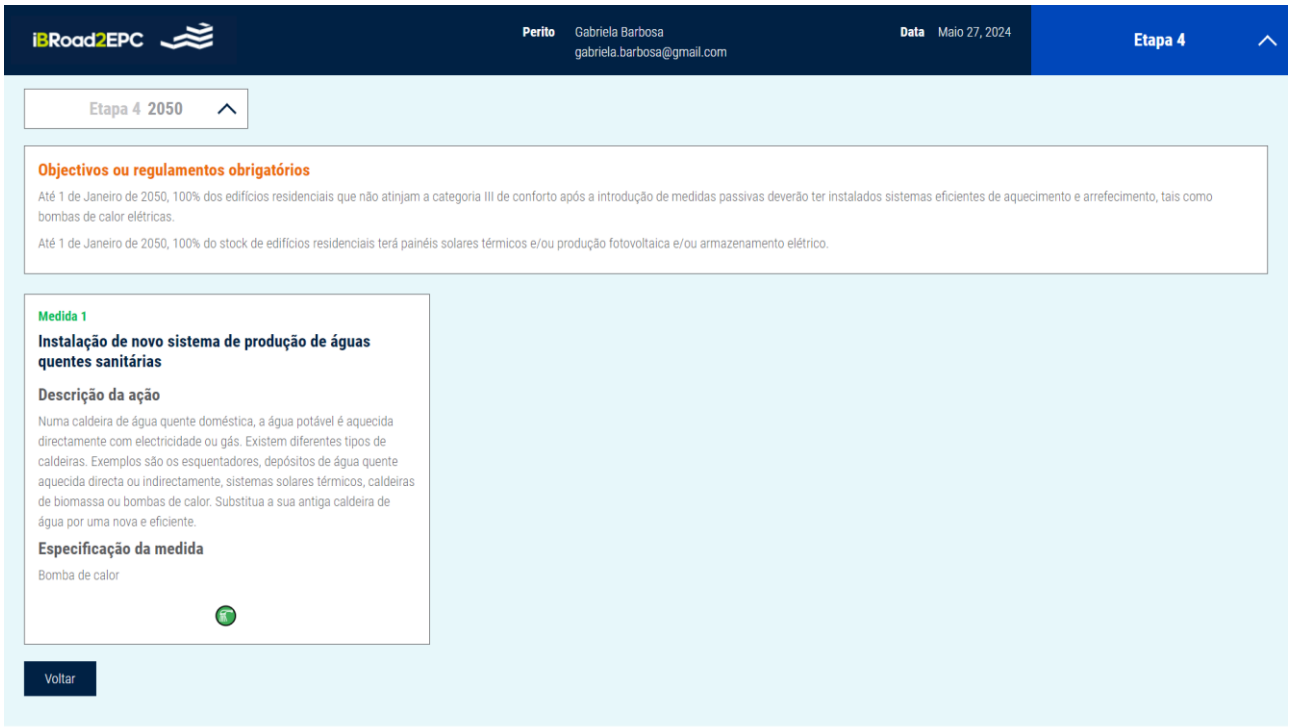
Voltar

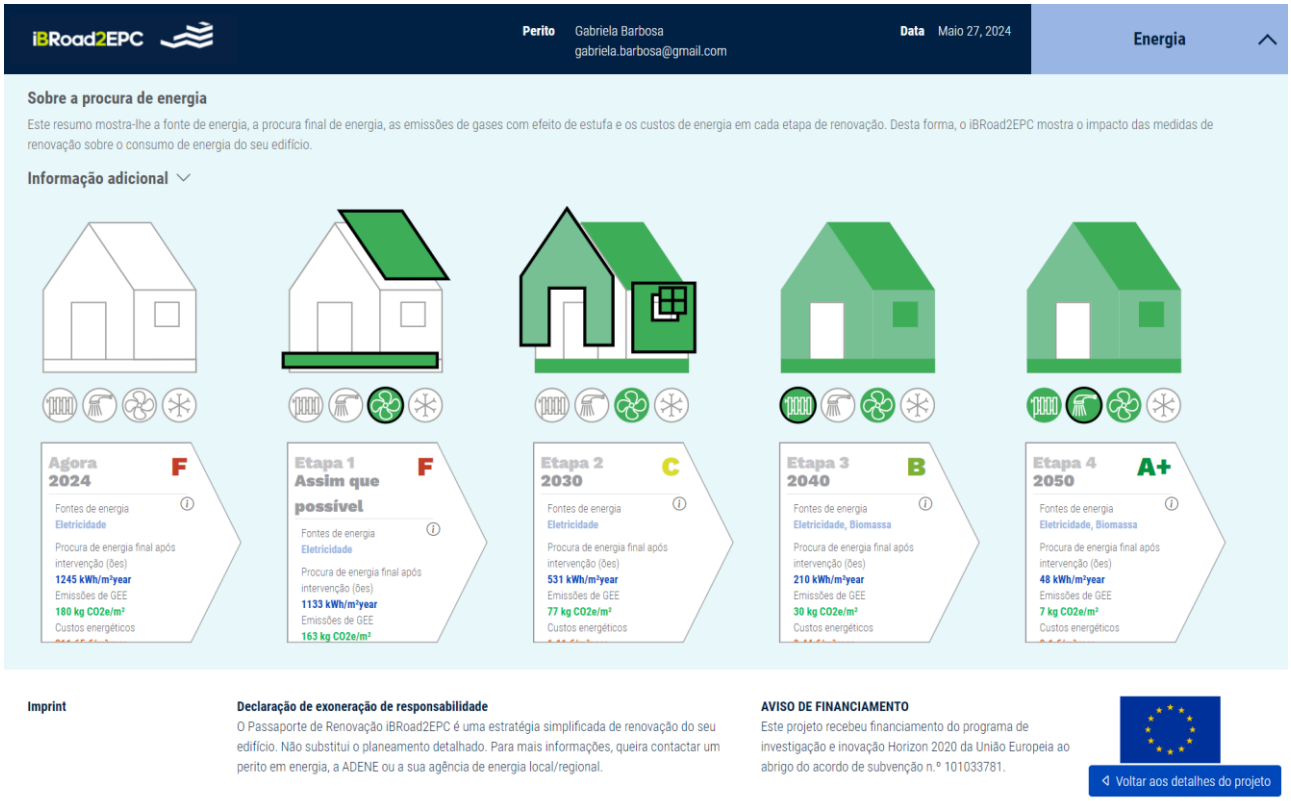
Imprint

Declaração de exoneração de responsabilidade
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iBRoad2EPC
Perito Gabriela Barbosa
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Data Maio 27, 2024
Etapa 3
Etapa 3 2040
Objectivos ou regulamentos obrigatórios
Até 1 de Janeiro de 2040, 77% dos edifícios residenciais que não atinjam a categoria III de conforto após a introdução de medidas passivas terão de dispor de sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas. Todos os sistemas de gás e gasóleo deverão ter sido substituídos por sistemas elétricos.
Até 1 de Janeiro de 2040, 75% do stock do edifícios residenciais terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.
Até 1 de Janeiro de 2040, os edifícios residenciais construídos antes de 2016 deverão atingir pelo menos a categoria III de conforto através da introdução de medidas passivas na envolvente (isolamento, janelas eficientes, etc.).
Até 1 de Janeiro de 2040, 100% dos edifícios residenciais deverão ter substituído toda a iluminação por LED e ter renovado os eletrodomésticos para equipamentos altamente eficientes.
Medida 1
Salamandra a lenha
Descrição da ação
Instalação e montagem de uma salamandra a lenha. É operado independentemente de outros geradores de calor. Certifique-se de que a salamadra cumpre os requisitos de protecção contra emissões e de protecção contra incêndios. Assegurar-se de que existe um abastecimento suficiente de ar de combustão.
Especificação da medida
A potência deve ser dimensionada para o seu edifício.
Voltar
Imprint
Declaração de exoneração de responsabilidade
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iBRoad2EPC
Perito Gabriela Barbosa
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Data Maio 27, 2024
Etapa 4
Etapa 4 2050
Objectivos ou regulamentos obrigatórios
Até 1 de Janeiro de 2050, 100% dos edifícios residenciais que não atinjam a categoria III de conforto após a introdução de medidas passivas deverão ter instalados sistemas eficientes de aquecimento e arrefecimento, tais como bombas de calor elétricas.
Até 1 de Janeiro de 2050, 100% do stock de edifícios residenciais terá painéis solares térmicos e/ou produção fotovoltaica e/ou armazenamento elétrico.
Medida 1
Instalação de novo sistema de produção de águas quentes sanitárias
Descrição da ação
Numa caldeira de água quente doméstica, a água potável é aquecida directamente com electricidade ou gás. Existem diferentes tipos de caldeiras. Exemplos são os esquentadores, depósitos de água quente aquecida directa ou indirectamente, sistemas solares térmicos, caldeiras de biomassa ou bombas de calor. Substitua a sua antiga caldeira de água por uma nova e eficiente.
Especificação da medida
Bomba de calor
Voltar
Imprint
Declaração de exoneração de responsabilidade
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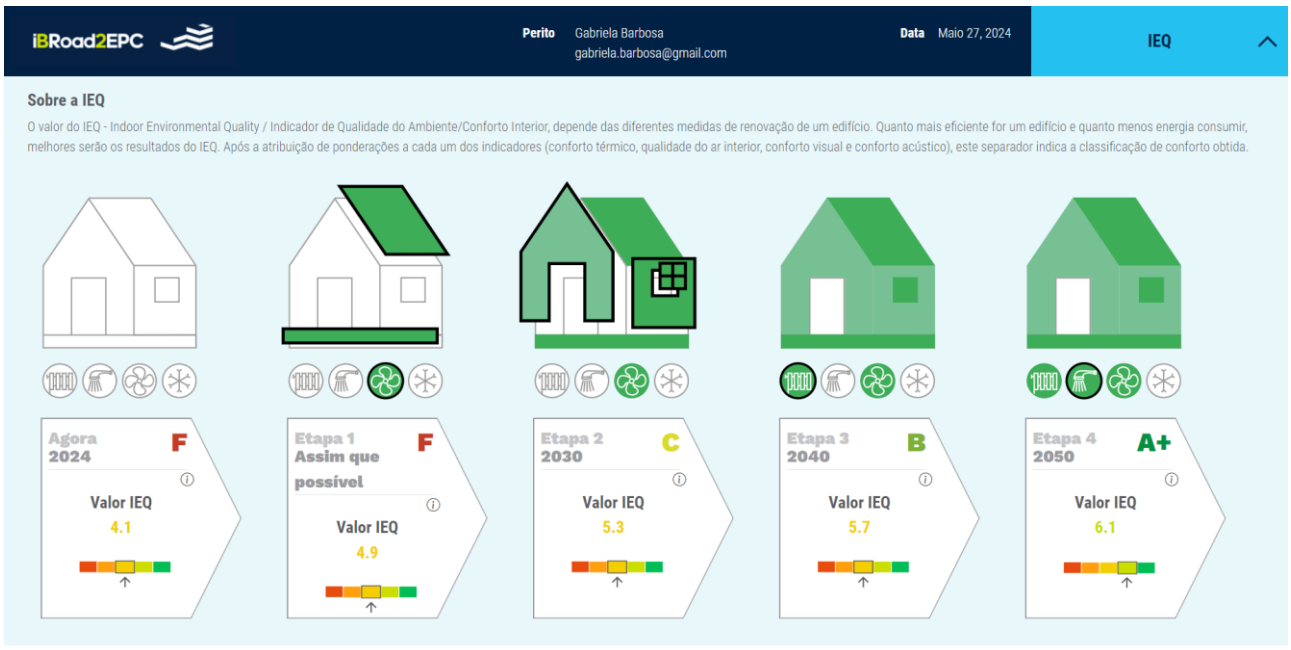


Imprint

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AVISO DE FINANCIAMENTO
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Voltar aos detalhes do projeto



Imprint

Declaração de exoneração de responsabilidade
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Voltar aos detalhes do projeto

ANNEX V- EPC House n°1

Certificar é Valorizar
CERTIFICAÇÃO ENERGÉTICA DOS EDIFÍCIOS

Certificado Energético
Edifício de Habitação

TEMP353810020



IDENTIFICAÇÃO POSTAL
Morada RUA CAMPO ALEGRE, 442, CASA 1
Localidade PORTO
Freguesia LORDELO DO OURO E MASSARELOS
Concelho PORTO — GPS 41.152956, -8.633923

IDENTIFICAÇÃO PREDIAL/FISCAL
Conservatória do Registo Predial Omissa
Nº de Inscrição na Conservatória -
Artigo Matricial nº 1199 — Fração Autónoma

INFORMAÇÃO ADICIONAL
Área Total de Pavimento 24,97 m²

Este certificado apresenta a classificação energética deste edifício ou fração. Esta classificação é calculada comparando o desempenho energético deste edifício nas condições atuais, com o desempenho que este obteria nas condições mínimas (com base em valores de referência ou requisitos aplicáveis para o ano assinalado) a que estão obrigados os edifícios novos. Saiba mais no site da ADENE em www.adene.pt.

IMPRESSÃO DE TESTE (sem valor legal)

INDICADORES DE DESEMPENHO

Determinam a classe energética do edifício e a eficiência na utilização de energia, incluindo o contributo de fontes renováveis. São apresentados comparativamente a um valor de referência e calculados em condições padrão.

Aquecimento Ambiente

Referência:	97 kWh/m².ano
Edifício:	394 kWh/m².ano
Renovável	- %

250% MENOS eficiente que a referência

Arrefecimento Ambiente

Referência:	3,0 kWh/m².ano
Edifício:	2,9 kWh/m².ano
Renovável	- %

6% MAIS eficiente que a referência

Água Quente Sanitária

Referência:	75 kWh/m².ano
Edifício:	104 kWh/m².ano
Renovável	- %

38% MENOS eficiente que a referência

CLASSE ENERGÉTICA

Mais eficiente

Julho 2006 | Dez. 2013 | Jan. 2016 | Julho 2021

A+ 0% a 25%
A 26% a 50%
Mínimo: Edifícios Novos
B 51% a 75%
B- 76% a 100%
C 101% a 150%
Mínimo: Grd. Renovação
D 151% a 200%
E 201% a 250%
F Mais de 251%

F 284%

ENERGIA RENOVÁVEL

Contributo de energia renovável no consumo de energia deste edifício.

0%

EMISSÕES DE CO_2

Emissões de CO_2 estimadas devido ao consumo de energia.

4,50 toneladas/ano

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Direção Geral de Energia e Geologia

1 de 8

Certificar é Valorizar
CERTIFICAÇÃO ENERGÉTICA DOS EDIFÍCIOS

Certificado Energético

Edifício de Habitação

TEMP353810020

F

DESCRIÇÃO SUCINTA DO EDIFÍCIO OU FRAÇÃO

Fração de habitação, de um edifício de unifamiliar, sendo o ano de construção determinado pelo ano de inscrição na matriz da CPU, de 1987, localizada no Porto, a uma altitude de 72 metros, situada no interior de uma zona urbana, com distância à costa inferior a 5 km, composta por dois pisos, de tipologia T2, com 24,97 m2 de área útil, constituída essencialmente por, no piso superior: dois quartos, uma sala e uma cozinha, tendo ainda como espaços não-úteis um arrumo no piso inferior. A fração apresenta inércia térmica médio, confronta com ENU de outro fogo e possui envolvente principal exterior orientada a todos os quadrantes, existindo obstáculos que provocam alguns sombreamentos importantes. A ventilação é natural. O sistema de preparação de águas quentes sanitárias é efectuado com recurso a um termoacumulador elétrico. A fração não possuiu sistema de climatização.

IMPRESSÃO DE TESTE (sem validade legal)

COMPORTAMENTO TÉRMICO DOS ELEMENTOS CONSTRUTIVOS DA HABITAÇÃO

Descreve e classifica o comportamento térmico dos elementos construtivos mais representativos desta habitação. Uma classificação de 5 estrelas, expressa a referência adequada para esses elementos, tendo em conta, entre outros factores, as condições climáticas onde o edifício se localiza.

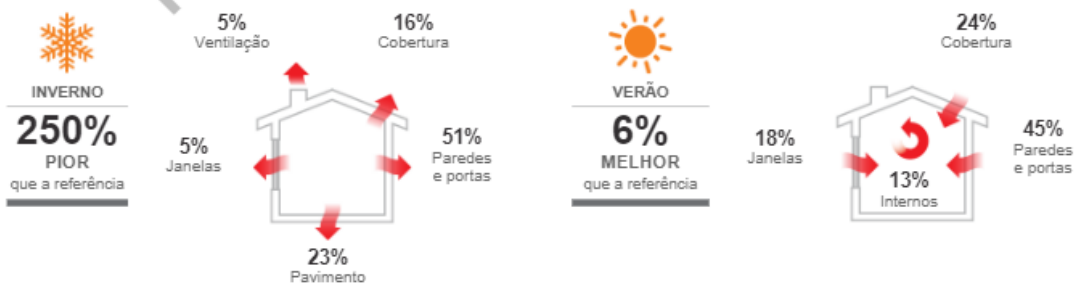
Tipo	Descrição das Principais Soluções	Classificação
PAREDES	Parede simples sem isolamento térmico	☆☆☆☆☆
COBERTURAS	Cobertura horizontal sem isolamento térmico	☆☆☆☆☆
PAVIMENTOS	Pavimento sem isolamento térmico	☆☆☆☆☆
JANELAS	Janela Simples com Caixilharia metálica sem corte térmico com vidro simples e com proteção solar pelo exterior	☆☆☆☆☆

Soluções sem isolamento, referem-se a soluções onde não existe isolamento térmico ou que não foi possível comprovar a sua existência.
A classificação de janelas, inclui o contributo de eventuais dispositivos de oclusão noturna.

Pior ☆☆☆☆☆
Melhor ★★★★★

PERDAS E GANHOS DE CALOR DA HABITAÇÃO

Os elementos construtivos contribuem para o consumo de energia associado à climatização e para o conforto na habitação. A informação apresentada, indica o contributo desses elementos, bem como, os locais onde ocorrem perdas e ganhos de calor.



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ANNEX VI- EPC House n°3

Certificar é Valorizar
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Certificado Energético
Edifício de Habitação

TEMP325201821



IDENTIFICAÇÃO POSTAL
Morada R DO CAMPO ALEGRE, 442
Localidade PORTO
Freguesia LORDELO DO OURO E MASSARELOS
Concelho PORTO — GPS 41.152964, -8.634028

IDENTIFICAÇÃO PREDIAL/FISCAL
1 ª Conservatória do Registo Predial de PORTO
Nº de Inscrição na Conservatória 795
Artigo Matricial nº 01002 — Fração Autónoma

INFORMAÇÃO ADICIONAL
Área Total de Pavimento 28,96 m²

Este certificado apresenta a classificação energética deste edifício ou fração. Esta classificação é calculada comparando o desempenho energético deste edifício nas condições atuais, com o desempenho que este obteria nas condições mínimas (com base em valores de referência ou requisitos aplicáveis para o ano assinalado) a que estão obrigados os edifícios novos. Saiba mais no site da ADENE em www.adene.pt.

IMPRESSÃO DE TESTE (sem valor legal)

INDICADORES DE DESEMPENHO

Determinam a classe energética do edifício e a eficiência na utilização de energia, incluindo o contributo de fontes renováveis. São apresentados comparativamente a um valor de referência e calculados em condições padrão.

	Referência:	Edifício: Renovável
Aquecimento Ambiente	57 kWh/m².ano	224 kWh/m².ano - %
Arrefecimento Ambiente	3,0 kWh/m².ano	3,7 kWh/m².ano - %
Água Quente Sanitária	43 kWh/m².ano	59 kWh/m².ano - %

250% MENOS eficiente que a referência

22% MENOS eficiente que a referência

37% MENOS eficiente que a referência

CLASSE ENERGÉTICA

Mais eficiente

Julho 2006 | Dez. 2013 | Jan. 2016 | Julho 2021

- A+ 0% a 25%
- A 26% a 50%
- Mínimo: Edifícios Novos
- B 51% a 75%
- B- 76% a 100%
- C 101% a 150%
- Mínimo: Grd. Renovação
- D 151% a 200%
- E 201% a 250%
- F Mais de 251%

F 280%

ENERGIA RENOVÁVEL

Contributo de energia renovável no consumo de energia deste edifício.

0%

EMISSÕES DE CO_2

Emissões de CO_2 estimadas devido ao consumo de energia.

3,00 toneladas/ano

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Entidade Fiscalizadora
Direção Geral de Energia e Geologia

1 de 9

Certificar é Valorizar
CERTIFICAÇÃO ENERGÉTICA DOS EDIFÍCIOS

Certificado Energético

Edifício de Habitação

TEMP353658535

F

DESCRIÇÃO SUCINTA DO EDIFÍCIO OU FRAÇÃO

Fração de habitação, de um edifício de unifamiliar, sendo o ano de construção determinado pelo ano de inscrição na matriz da CPU, de 1987, localizada no Porto, a uma altitude de 72 metros, situada no interior de uma zona urbana, com distância à costa inferior a 5 km, composta por dois pisos, de tipologia T2, com 24,97 m2 de área útil, constituída essencialmente por, no piso terreo um quarto, uma sala tendo e um arrumo e no piso superior o segundo quarto. A cozinha e a I.S. encontram-se fora do alojamento. A fração apresenta inércia térmica médio, confronta com ENU de outros fogos e possui envolvente principal exterior orientada a Norte, não existindo obstáculos que provocam sombreamentos.. A ventilação é natural. O sistema de preparação de águas quentes sanitárias é efectuado com recurso a um termoacumulador elétrico. A fração não possuiu sistema de climatização.

IMPRESSÃO DE TESTE (sem validade legal)

COMPORTAMENTO TÉRMICO DOS ELEMENTOS CONSTRUTIVOS DA HABITAÇÃO

Descreve e classifica o comportamento térmico dos elementos construtivos mais representativos desta habitação. Uma classificação de 5 estrelas, expressa a referência adequada para esses elementos, tendo em conta, entre outros factores, as condições climáticas onde o edifício se localiza.

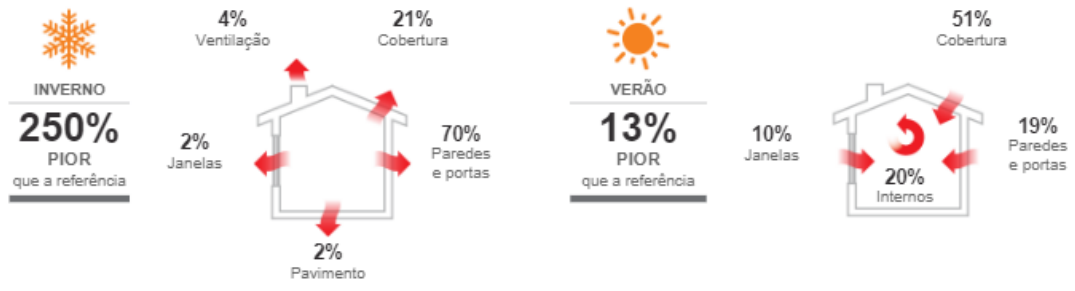
Tipo	Descrição das Principais Soluções	Classificação
PAREDES	Parede simples de alvenaria de pedra e argamassa	☆☆☆☆☆
COBERTURAS	Cobertura horizontal sem isolamento térmico	☆☆☆☆☆
	Cobertura inclinada sem isolamento térmico	☆☆☆☆☆
PAVIMENTOS	Pavimento sem isolamento térmico	★★★★★
JANELAS	Janela Simples com Caixilharia de madeira com vidro simples e com proteção solar pelo exterior	☆☆☆☆☆
	Janela Simples com Caixilharia metálica sem corte térmico com vidro simples e sem proteção solar	☆☆☆☆☆

Soluções sem isolamento, referem-se a soluções onde não existe isolamento térmico ou que não foi possível comprovar a sua existência.
A classificação de janelas, inclui o contributo de eventuais dispositivos de oclusão noturna.

Pior ☆☆☆☆☆
Melhor ★★★★★

PERDAS E GANHOS DE CALOR DA HABITAÇÃO

Os elementos construtivos contribuem para o consumo de energia associado à climatização e para o conforto na habitação. A informação apresentada, indica o contributo desses elementos, bem como, os locais onde ocorrem perdas e ganhos de calor.



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Direção Geral de Energia e Geologia

ANNEX VII- EPC House n° 5

Certificar é Valorizar
CERTIFICAÇÃO ENERGÉTICA DOS EDIFÍCIOS

Certificado Energético
Edifício de Habitação

TEMP353658535



IDENTIFICAÇÃO POSTAL
Morada RUA CAMPO ALEGRE, 442, CASA 5
Localidade PORTO
Freguesia LORDELO DO OURO E MASSARELOS
Concelho PORTO — GPS 41.152956, -8.633923

IDENTIFICAÇÃO PREDIAL/FISCAL
Conservatória do Registo Predial Omissa
Nº de Inscrição na Conservatória -
Artigo Matricial nº 1203 — Fração Autónoma

INFORMAÇÃO ADICIONAL
Área Total de Pavimento 25,33 m²

Este certificado apresenta a classificação energética deste edifício ou fração. Esta classificação é calculada comparando o desempenho energético deste edifício nas condições atuais, com o desempenho que este obteria nas condições mínimas (com base em valores de referência ou requisitos aplicáveis para o ano assinalado) a que estão obrigados os edifícios novos. Saiba mais no site da ADENE em www.adene.pt.

IMPRESSÃO DE TESTE (sem valor legal)

INDICADORES DE DESEMPENHO

Determinam a classe energética do edifício e a eficiência na utilização de energia, incluindo o contributo de fontes renováveis. São apresentados comparativamente a um valor de referência e calculados em condições padrão.

Aquecimento Ambiente

Referência:	70 kWh/m².ano
Edifício:	309 kWh/m².ano
Renovável	- %

250% MENOS eficiente que a referência

Arrefecimento Ambiente

Referência:	3,0 kWh/m².ano
Edifício:	3,4 kWh/m².ano
Renovável	- %

13% MENOS eficiente que a referência

Água Quente Sanitária

Referência:	74 kWh/m².ano
Edifício:	97 kWh/m².ano
Renovável	- %

30% MENOS eficiente que a referência

CLASSE ENERGÉTICA

Mais eficiente

Julho 2006 | Dez. 2013 | Jan. 2016 | Julho 2021

- A+ 0% a 25%
- A 26% a 50%
- Mínimo: Edifícios Novos
- B 51% a 75%
- B- 76% a 100%
- C 101% a 150%
- Mínimo: Grd. Renovação
- D 151% a 200%
- E 201% a 250%
- F Mais de 251%

F 277%

ENERGIA RENOVÁVEL

Contributo de energia renovável no consumo de energia deste edifício.

0%

EMISSÕES DE CO_2

Emissões de CO_2 estimadas devido ao consumo de energia.

3,73 toneladas/ano

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Entidade Fiscalizadora
Direção Geral de Energia e Geologia

1 de 7

Certificar é Valorizar
CERTIFICAÇÃO ENERGÉTICA DOS EDIFÍCIOS

Certificado Energético

Edifício de Habitação

TEMP353658535

F

DESCRIÇÃO SUCINTA DO EDIFÍCIO OU FRAÇÃO

Fração de habitação, de um edifício de unifamiliar, sendo o ano de construção determinado pelo ano de inscrição na matriz da CPU, de 1987, localizada no Porto, a uma altitude de 72 metros, situada no interior de uma zona urbana, com distância à costa inferior a 5 km, composta por dois pisos, de tipologia T2, com 24,97 m2 de área útil, constituída essencialmente por, no piso terreo um quarto, uma sala tendo e um arrumo e no piso superior o segundo quarto. A cozinha e a I.S. encontram-se fora do alojamento. A fração apresenta inércia térmica médio, confronta com ENU de outros fogos e possui envolvente principal exterior orientada a Norte, não existindo obstáculos que provocam sombreamentos.. A ventilação é natural. O sistema de preparação de águas quentes sanitárias é efectuado com recurso a um termoacumulador elétrico. A fração não possuiu sistema de climatização.

IMPRESSÃO DE TESTE (sem validade legal)

COMPORTAMENTO TÉRMICO DOS ELEMENTOS CONSTRUTIVOS DA HABITAÇÃO

Descreve e classifica o comportamento térmico dos elementos construtivos mais representativos desta habitação. Uma classificação de 5 estrelas, expressa a referência adequada para esses elementos, tendo em conta, entre outros factores, as condições climáticas onde o edifício se localiza.

Tipo	Descrição das Principais Soluções	Classificação
PAREDES	Parede simples de alvenaria de pedra e argamassa	☆☆☆☆☆
COBERTURAS	Cobertura horizontal sem isolamento térmico	☆☆☆☆☆
	Cobertura inclinada sem isolamento térmico	☆☆☆☆☆
PAVIMENTOS	Pavimento sem isolamento térmico	★★★★★
JANELAS	Janela Simples com Caixilharia de madeira com vidro simples e com proteção solar pelo exterior	☆☆☆☆☆
	Janela Simples com Caixilharia metálica sem corte térmico com vidro simples e sem proteção solar	☆☆☆☆☆

Soluções sem isolamento, referem-se a soluções onde não existe isolamento térmico ou que não foi possível comprovar a sua existência.
A classificação de janelas, inclui o contributo de eventuais dispositivos de oclusão noturna.

Pior ☆☆☆☆☆
Melhor ★★★★★

PERDAS E GANHOS DE CALOR DA HABITAÇÃO

Os elementos construtivos contribuem para o consumo de energia associado à climatização e para o conforto na habitação. A informação apresentada, indica o contributo desses elementos, bem como, os locais onde ocorrem perdas e ganhos de calor.



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Entidade Fiscalizadora
Direção Geral de Energia e Geologia

ANNEX VIII- EPC House nº 13

Certificar é Valorizar
CERTIFICAÇÃO ENERGÉTICA DOS EDIFÍCIOS

Certificado Energético
Edifício de Habitação

TEMP345656029



IDENTIFICAÇÃO POSTAL
Morada RUA CAMPO ALEGRE, 442
Localidade PORTO
Freguesia LORDELO DO OURO E MASSARELOS
Concelho PORTO — GPS 41.152956, -8.633923

IDENTIFICAÇÃO PREDIAL/FISCAL
Conservatória do Registo Predial Omissa
Nº de Inscrição na Conservatória -
Artigo Matricial nº 1020 — Fração Autónoma

INFORMAÇÃO ADICIONAL
Área Total de Pavimento 24,97 m²

Este certificado apresenta a classificação energética deste edifício ou fração. Esta classificação é calculada comparando o desempenho energético deste edifício nas condições atuais, com o desempenho que este obteria nas condições mínimas (com base em valores de referência ou requisitos aplicáveis para o ano assinalado) a que estão obrigados os edifícios novos. Saiba mais no site da ADENE em www.adene.pt.

IMPRESSÃO DE TESTE (sem valor legal)

INDICADORES DE DESEMPENHO

Determinam a classe energética do edifício e a eficiência na utilização de energia, incluindo o contributo de fontes renováveis. São apresentados comparativamente a um valor de referência e calculados em condições padrão.

Aquecimento Ambiente

Referência:	97 kWh/m².ano
Edifício:	394 kWh/m².ano
Renovável	- %

250% MENOS eficiente que a referência

Arrefecimento Ambiente

Referência:	3,0 kWh/m².ano
Edifício:	2,9 kWh/m².ano
Renovável	- %

6% MAIS eficiente que a referência

Água Quente Sanitária

Referência:	75 kWh/m².ano
Edifício:	104 kWh/m².ano
Renovável	- %

38% MENOS eficiente que a referência

CLASSE ENERGÉTICA

Mais eficiente

Julho 2006 | Dez. 2013 | Jan. 2016 | Julho 2021

- A+ 0% a 25%
- A 26% a 50%
- Mínimo: Edifícios Novos
- B 51% a 75%
- B- 76% a 100%
- C 101% a 150%
- Mínimo: Grd. Renovação
- D 151% a 200%
- E 201% a 250%
- F Mais de 251% — **F** 284%

ENERGIA RENOVÁVEL

Contributo de energia renovável no consumo de energia deste edifício.

0%

EMISSÕES DE CO_2

Emissões de CO_2 estimadas devido ao consumo de energia.

4,50 toneladas/ano

Entidade Gestora
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Agência para a Energia

Entidade Fiscalizadora
Direção Geral de Energia e Geologia

1 de 7

Certificar é Valorizar
CERTIFICAÇÃO ENERGÉTICA DOS EDIFÍCIOS

Certificado Energético

Edifício de Habitação

TEMP345656029

F

DESCRIÇÃO SUCINTA DO EDIFÍCIO OU FRAÇÃO

Fração de habitação, de um edifício de unifamiliar, sendo o ano de construção determinado pelo ano de inscrição na matriz da CPU, de 1987, localizada no Porto, a uma altitude de 72 metros, situada no interior de uma zona urbana, com distância à costa inferior a 5 km, composta por dois pisos, de tipologia T2, com 24,97 m2 de área útil, constituída essencialmente por, no piso superior: dois quartos, uma sala e uma cozinha, tendo ainda como espaços não-úteis um arrumo no piso inferior. A fração apresenta inércia térmica médio, confronta com ENU de outro fogo e possui envolvente principal exterior orientada a todos os quadrantes, existindo obstáculos que provocam alguns sombreamentos importantes. A ventilação é natural. O sistema de preparação de águas quentes sanitárias é efectuado com recurso a um termoacumulador elétrico. A fração não possuiu sistema de climatização.

IMPRESSÃO DE TESTE (sem validade legal)

COMPORTAMENTO TÉRMICO DOS ELEMENTOS CONSTRUTIVOS DA HABITAÇÃO

Descreve e classifica o comportamento térmico dos elementos construtivos mais representativos desta habitação. Uma classificação de 5 estrelas, expressa a referência adequada para esses elementos, tendo em conta, entre outros factores, as condições climáticas onde o edifício se localiza.

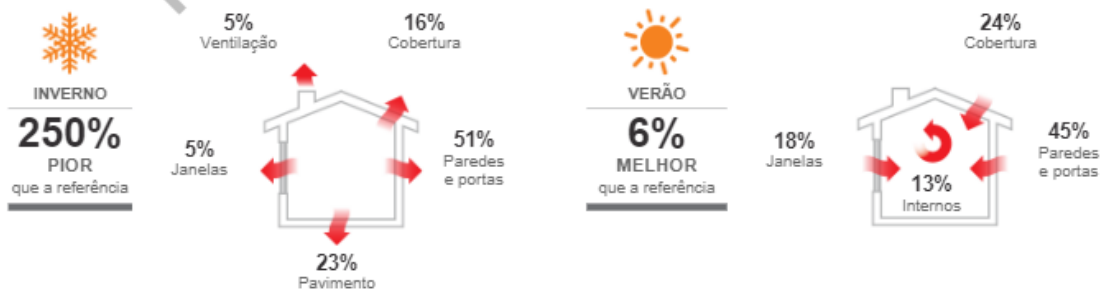
Tipo	Descrição das Principais Soluções	Classificação
PAREDES	Parede simples sem isolamento térmico	☆☆☆☆☆
COBERTURAS	Cobertura horizontal sem isolamento térmico	☆☆☆☆☆
PAVIMENTOS	Pavimento sem isolamento térmico	☆☆☆☆☆
JANELAS	Janela Simples com Caixilharia metálica sem corte térmico com vidro simples e com proteção solar pelo exterior	☆☆☆☆☆

Soluções sem isolamento, referem-se a soluções onde não existe isolamento térmico ou que não foi possível comprovar a sua existência.
A classificação de janelas, inclui o contributo de eventuais dispositivos de oclusão noturna.

Pior ☆☆☆☆☆
Melhor ★★★★★

PERDAS E GANHOS DE CALOR DA HABITAÇÃO

Os elementos construtivos contribuem para o consumo de energia associado à climatização e para o conforto na habitação. A informação apresentada, indica o contributo desses elementos, bem como, os locais onde ocorrem perdas e ganhos de calor.



Entidade Gestora
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Entidade Fiscalizadora
Direção Geral de Energia e Geologia