04/03/2025

Rural Energy Efficiency Roadmap - REER

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Published in 2023 by RENOVERTY.

About RENOVERTY

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

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

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

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Background to the Area of Study and the purpose of the REER

The Rural Energy Efficiency Roadmap (REER) involves 7 European countries and 17 selected rural areas, with the goal of creating actionable roadmaps to renovate residential buildings in rural regions. The primary objective of the roadmaps is to provide citizens with practical guidance for improving the energy efficiency of their homes, reducing energy costs and addressing energy poverty. The roadmaps are also intended for stakeholders working to combat energy poverty, offering adaptable tools that can be tailored to specific regional needs. In Italy, the province of Parma was chosen as the reference area due to its aging and energy-inefficient building stock.

Parma, located in the heart of the Po Valley – a region that accounts for approximately 40% of Italy's population (around 23 million people) and generates close to 50% of the national GDP – is part of one of Italy's most densely populated and productive areas. However, the region's orographic and anthropogenic features make it particularly vulnerable to air pollution. Air quality in the province frequently exceeds legal thresholds (Directive 2008/50/EC, transposed with Legislative Decree 155/2010), prompting the EU to initiate an infringement procedure (n°2014/2147 and subsequent actions). This area includes 24 municipalities in the province of Parma among the total 195 involved.

The province is divided into three main areas: the fertile Po Valley to the north, which is well-suited for agriculture; the central hilly belt and the Apennines to the south, characterized by small villages and vast agricultural and forested districts. Major rivers, such as the Taro and Parma, enhance the area's suitability for agricultural development and water resource management. The climate is continental, with hot, humid summers and cold winters, with peak rainfall occurring in autumn and spring. In 2024, Parma, Italy, experienced an average annual temperature of approximately 13.7 °C, while the highest temperature recorded during the year was 34.4 °C and the lowest was -1.1 °C

The population of approximately 450,000 residents is predominantly concentrated in the provincial capital, Parma, which serves as the economic, cultural and administrative centre of the province. The plains are densely populated, while the hilly and mountainous areas exhibit a more sparse and scattered population. Over recent decades, an increase in the immigrant population has contributed to the local social and cultural diversity.

From a socio-economic perspective, Parma is a leader in the agri-food sector. Iconic products like Parmigiano Reggiano and Prosciutto di Parma make agriculture and food processing key pillars of the local economy. Additionally, the province is home to international companies in the mechanical, chemical and pharmaceutical sectors, including Chiesi and Lilly, and the capital is a major hub for services, commerce and tourism.

Despite this robust economic foundation, rural and mountainous areas of the province face significant challenges, including an outdated building stock and widespread energy poverty. An analysis of the residential building stock reveals that much of it is obsolete, having been constructed before 1976, the year energy efficiency regulation the law 373/76 were introduced.

Currently, around 90% of homes are equipped with heating and/or domestic hot water systems, with 77% relying on methane as the primary fuel. However, rural areas, which are only partially served by the methane network, often use alternative fuels such as Liquefied petroleum gas (LPG), diesel and wood. Furthermore, 75% of Energy Performance Certificates (EPCs) issued in the province fall into the least efficient energy classes - E, F and G - highlighting particularly poor performance in terms of energy loss through opaque and transparent surfaces. Renovating these elements is challenging due to high costs and technical complexity, resulting in a low renovation rate for buildings.

The RENOVERTY project emphasizes the need for long-term, structural interventions to improve air quality and reduce energy consumption and emissions in the residential sector. Additionally, challenges arising during the COVID-19 pandemic underscored the importance of improving domestic environments - not only to reduce consumption and costs but also to enhance the quality of life of households, particularly for the most vulnerable sections of the population.

The document is divided into two parts. The first part details the work carried out in collaboration with the Territorial Agency for Energy and Sustainability of Parma (Agenzia Territoriale per l’Energia e la Sostenibilità - ATES) and the Local Action Group (LAG) "GAL del Ducato". It covers the types of buildings selected, the inspections and energy audits conducted, and the meetings held with property owners. Additionally, it outlines the main obstacles encountered during the process, the solutions developed to overcome them, the energy efficiency measures proposed, and their projected impact on energy consumption and emissions.

The second part provides a broader overview of renovation objectives, potential barriers, and challenges, which may vary by area, along with suggestions on how to address them. This section also identifies key stakeholders, from local to national levels, who should be involved in the co-creation of solutions. Finally, it outlines strategies for promoting scalability, replicability and dissemination of the roadmaps.

As the two parts share some overlapping sections, it is recommended to consult the first part for a detailed, predominantly technical analysis supported by data, graphs and models. Conversely, those seeking general guidelines for constructing REERs and solutions to common challenges can refer directly to the second part for practical insights.

1. Technical Considerations for Renovating Homes Affected by Energy Poverty

In Italy, the definition of energy poverty corresponds to that found in Directive (EU) 2023/1791, which states that it is the

"inability of a household to access essential energy services that provide basic levels and decent standards of living and health, including an adequate supply of heating, hot water, cooling lighting, and energy to power appliances, within the respective national context of existing national social policy and other relevant national policies, due to a combination of factors, including at least economic inaccessibility, insufficient disposable income, high energy expenditures, and poor household energy efficiency."

This definition has also been included within the National Integrated Energy and Climate Plan (PNIEC), and in its latest version, the "share of the total population unable to adequately heat their homes" is taken as an indicator.

1.1. Energy Audits

The energy certification of buildings evaluates the energy quality of a property to promote efficiency through a detailed analysis of its performance. This process culminates in the issuance of an Energy Performance Certificate (EPC), prepared by a qualified technician after a comprehensive building inspection. The EPC, mandatory for the sale or rental of entire buildings, provides essential information such as the building's overall energy performance, energy class, energy demand, CO_2 emissions, and recommendations for improvements. The energy class is determined by the global non-renewable energy performance index (EPgl,nr), with higher classes indicating lower consumption and greater efficiency. In addition to enhancing transparency in the real estate market, the EPC identifies measures to improve energy efficiency, thereby reducing costs and emissions.

To prepare the EPC, certified technicians gather documentation, including the cadastral survey, floor plans, and the system's booklet. They conduct an inspection to evaluate the building's energy-related features, such as wall stratigraphy, construction details, and system specifications. Using software certified by the Italian Thermotechnical Committee (CTI), they calculate the global energy performance index and assign the energy class. The technician also proposes interventions to improve the property's energy efficiency. The EPC must be registered in the regional energy certification system and remains valid for up to 10 years, unless updates are required due to renovation works.

To represent the diversity of building types in the province, an analysis was conducted considering construction periods, building types (single or multi-family), envelope characteristics, heating systems (autonomous or centralized), and historical-testimonial value. Five main building categories were identified:

1. Single-storey detached buildings (two-family) constructed before 1980, featuring reinforced concrete load-bearing structures with brick infills.
2. Multi-storey detached buildings built before 1945, characterized by exposed stone structures (of historical value) and autonomous heating systems.
3. Multi-storey detached buildings (condominiums) with at least six apartments, built before 1960, with solid brick or stone structures and autonomous heating systems.
4. Multi-storey detached buildings (condominiums) with at least six apartments, built before 1980 featuring reinforced concrete structures, brick infills and centralised heating.
5. Multi-storey row buildings constructed before 1945, with load-bearing structures and autonomous heating systems.

The selection of buildings for auditing was carried out in collaboration with the Local Action Group "GAL del Ducato", agricultural trade associations like Coldiretti and Confagricoltura (for single/two-family buildings), and the Territorial Agency for Energy and Sustainability of Parma (ATES) for condominium buildings in rural areas. The selected buildings are located in the municipalities of Fornovo, Solignano, Berceto, Bedonia, Tornolo and Albareto.

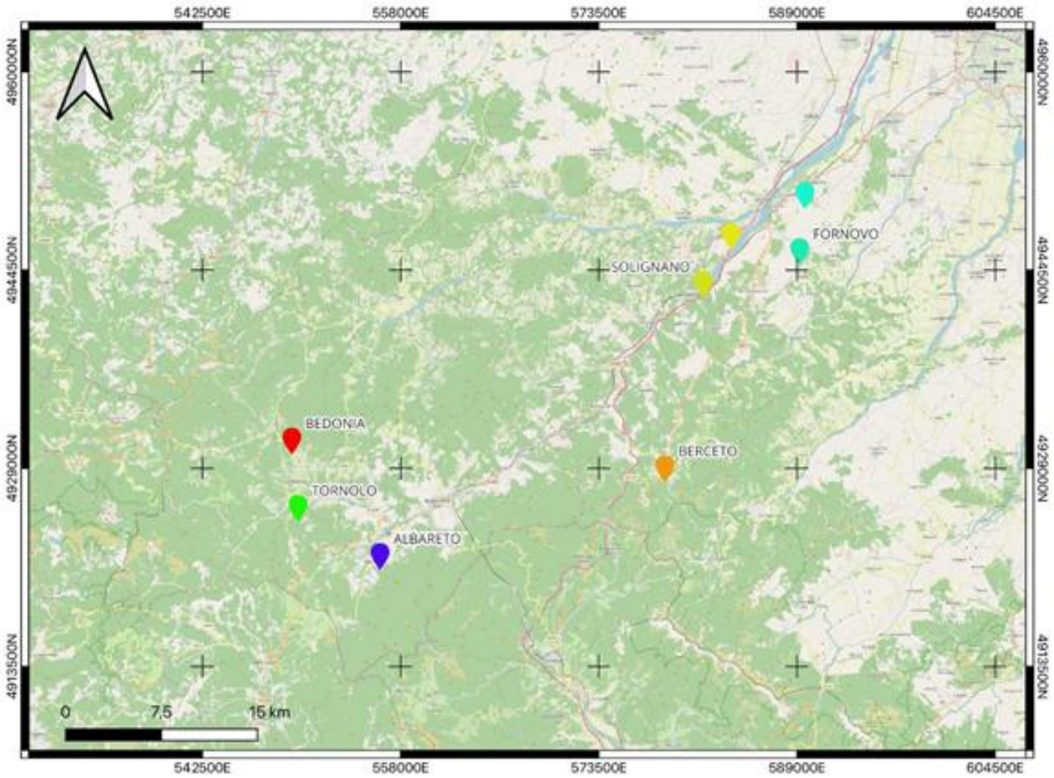


Figure 1: Map of municipalities

A total of 24 inspections were conducted, one for each apartment. These inspections collected data essential for developing a building-system model, which is fundamental for drafting the EPC. Local climatic conditions, specifications of opaque and transparent envelope elements (e.g., type, thickness and energy performance of walls, floors and windows), and air conditioning systems were analysed.

This data enabled the creation of 24 EPCs and the development of "expeditious audits" – streamlined reports that combine energy audits and EPC insights. These audits describe the current state of buildings and identify cost-effective measures to improve energy efficiency and performance.

1.1.1 Expeditious Audit of the 1st Building

The building is located in the Municipality of Albareto, in the southernmost part of the Province of Parma, in the locality of Case Mirani, north of the town of Albareto. The area is classified as climate zone F, with over 3,001 Degree Days and no restrictions on the hours or period of operation for air conditioning systems. Built in the early 1900s, the building consists of a basement and one above-ground floor intended as a residence. The load-bearing structure is made of stone and solid bricks, partially plastered, while the base and roof floors adjoin unheated spaces (cellar and attic). The building components lack thermal insulation. During the inspection, the building was found to have no windows, air conditioning systems, or lighting systems, resulting in an energy class G classification.

1.1.2 Expeditious Audit 2nd Building

The building is located in the Municipality of Bedonia, in the southwestern part of the Province of Parma. It falls within climate zone E (2,100-3,000 Degree Days), with air conditioning systems allowed to operate between October 15 and April 15 for a maximum of 14 hours per day. The building is located in Prato, north of the town of Bedonia, and was built at the beginning of the 1900s. It includes two above-ground floors intended as residential space. The load-bearing structure consists of stone and solid bricks, with a concrete slab for the ground floor and a wooden slab for the roof. The building elements lack thermal insulation. Windows are wooden, fitted with traditional double glazing. A recently installed air conditioning system consists of a 7.5 kW biomass stove. Domestic hot water is provided by an electric boiler, while lighting is supplied by LED lamps (approximately 20 W each). A 4.8 kW photovoltaic system is installed on the roof. The building is classified as energy class G.

1.1.3 Expeditious Audit of the 3rd Building

The building is located in the Municipality of Berceto, in a predominantly mountainous area classified as climate zone F, with over 3,001 Degree Days and no restrictions on the operation of air conditioning systems. Built in 1960, the building is situated in the town of Berceto and consists of three above-ground floors with a total of six apartments (two per floor). The load-bearing structure is made of reinforced concrete, with plastered perforated brick infills. The base and roof floors are constructed of brick and concrete, adjoining unheated spaces (cellar and attic). The building components lack thermal insulation. The windows, made with aluminium frames, have either single glazing or traditional double glazing. The autonomous air conditioning system includes a dated methane gas boiler (less than 35 kW) used for heating and domestic hot water. The lighting system uses traditional lamps (40-60 W). The building is classified as energy class G.

1.1.4 Expeditious Audit of the 4th Building

The building is located in the Municipality of Fornovo, in a hilly area at the confluence of the Taro and Ceno rivers, classified as climate zone E (2,100-3,000 Degree Days). Air conditioning systems operate from October 15 to April 15 for a maximum of 14 hours per day. The building, located in Riccò, east of the town of Fornovo, was constructed in 1960. It consists of a basement, used as cellars and garages, and three above-ground floors with a total of 12 apartments (four per floor). The load-bearing structure is made of reinforced concrete, with perforated brick infills. The base and roof floors are made of brick and concrete and adjoin unheated areas (cellar/garage and attic). The building lacks thermal insulation. Windows, made of wood, are equipped with single glazing. The centralized air conditioning system is powered by an outdated methane gas boiler (greater than 35 kW). The lighting system primarily consists of traditional lamps (40-60 W). The building is classified as energy class G.

1.1.5 Expeditious Audit of the 5th Building

The building is located in the Municipality of Fornovo, on the slopes of the Parma Apennines at the confluence of the Taro and Ceno rivers, in the locality of Vizzola, east of Riccò. It is classified as climate zone E (2,100-3,000 Degree Days), with air conditioning systems operating from October 15 to April 15 for a maximum of 14 hours per day. Built in 1900, the building consists of three above-ground floors intended as residences. The load-bearing structure is solid masonry, with base and roof slabs constructed of brick and cement adjoining unheated spaces (ground floor and attic). The building components lack thermal insulation. Windows, with wooden frames, are fitted with single glazing or traditional double glazing. The air conditioning system includes three condensing methane gas boilers installed in 2020. The lighting system uses traditional lamps (40-60 W). A 5.4 kW photovoltaic system was also installed in 2020. The building is classified as energy class G.

1.1.6 Expeditious Audit of the 6th and 7th Buildings

The building is located in the Municipality of Solignano, in the locality of Ravagnina, a hilly area between the Taro and Ceno rivers on the slopes of the Parma Apennines. It is classified as climate zone E (2,100-3,000 Degree Days), with air conditioning systems operating from October 15 to April 15 for a maximum of 14 hours per day. Built in 1975, the building is adjacent to an identical and symmetrical structure and consists of a single above-ground floor intended for housing. The load-bearing structure is made of reinforced concrete, with perforated block infills. The base and roof floors, made of brick and concrete, adjoin unheated spaces (cellar and attic). The building components lack thermal insulation. Windows, made with wooden frames, are equipped with single glazing. The autonomous air conditioning system is powered by a traditional LPG boiler (less than 35 kW), installed in 2010, for combined heating and domestic hot water production. The lighting system primarily uses traditional lamps (40-60 W). The building is classified as energy class G.

1.1.7 Expeditious Audit of the 8th Building

The building is located in the Municipality of Tornolo, a predominantly mountainous area classified as climate zone F, with over 3,001 Degree Days and no restrictions on the operation of air conditioning systems. Built in 1960 in the town of Tornolo, the building consists of a single above-ground floor intended for housing. The load-bearing structure is made of reinforced concrete, with perforated block infills in the original section and wooden infills in the extended section. The base and roof floors, made of brick and concrete, adjoin unheated spaces (cellar and attic). Windows, with wooden frames, are fitted with traditional double glazing. The autonomous air conditioning system includes a traditional methane gas boiler (less than 35kW) installed in 2021, for combined heating and domestic hot water production. Domestic hot water is supplemented by a solar thermal system with panels of approximately 2 square meters. The lighting system primarily uses traditional lamps (40W). The building is classified as energy class G.

1.2. Renovation Expectations and Indicators for Rural Households

The objectives and indicators for energy renovation of buildings serve as an essential guide to improving energy efficiency, reducing consumption, and lowering CO_2 emissions. Below, the primary objectives and associated indicators for monitoring the results of renovations are described. The use of these indicators allows for the monitoring of progress and outcomes of renovation efforts, ensuring measurable improvements in the energy efficiency of buildings.

Table 1: Objectives of Energy Renovation

Objectives of Energy Renovation	
Reduced Energy Consumption:	- Minimize the energy required for heating, cooling and lighting buildings. - Replace or optimize heating, ventilation, and air conditioning (HVAC) systems.
Reduction of CO_2 Emissions:	- Lower the environmental impact of buildings through improved energy efficiency and integration of renewable energy sources.
Improved Living Comfort:	- Achieve optimal indoor temperatures, enhanced air quality, and better sound insulation. - Reduce heat loss to ensure greater indoor climate stability. - Improve health and well-being by reducing presence of damp and mould.
Increased Share of Renewable Energy:	- Incorporate solar panels, photovoltaic systems, or geothermal systems to decrease reliance on traditional, non-renewable energy sources.
Economic Enhancement of Buildings:	- Elevate the energy class of buildings (e.g., A+, A), and the increasing of the value of the property for the owners. - Reduce long-term energy management costs. - Allow households to become prosumers.
Cost Savings for Users:	- Lower energy expenses through targeted efficiency improvements. - Opportunity for households to not be exposed to the effects of poverty or energy poverty.
Compliance with Energy Regulations:	- Adhere to European, national, and local energy efficiency directives, such as the Energy Performance of Buildings Directive (EPBD).

Indicators to Monitor the Success of Energy Renovation	
Energy Class:	- Measures the improvement in the building's energy classification (e.g., A+, A, B, C, etc.). - Reflects the overall efficiency of the building in terms of primary energy consumption. - **An ideal improvement corresponds to a jump of at least two energy classes (e.g., from G to E).**
Energy Consumption per Square Meter (kWh/m²/year):	- Indicates the annual energy consumption for heating, cooling, domestic hot water, and lighting per m². **Optimal values range between 50 and 90 kWh/m²/year.**
Reduction of CO_2 Emissions ($kgCO_2$/year):	- Quantifies the decrease in CO_2 emissions achieved through renovations. - **An optimal reduction falls between 30% and 50%.**
Thermal Insulation (Thermal Transmittance U - W/m²K):	- Assesses the quality of thermal insulation in walls, roofs and windows. Lower values indicate greater efficiency in reducing heat loss. - **Optimal values for thermal transmittance range between 0.20 and 0.30 W/m²K for walls and roofs.**
Share of Renewable Energy (%):	- Monitors the proportion of renewable energy in the building's total energy needs. - **The goal is to achieve a renewable energy share of 30% to 50%.**
Efficiency of Heating and Cooling Systems (COP/EER):	- The Coefficient of Performance (**COP**) for heating and the Energy Efficiency Ratio (**EER**) for cooling measure system efficiency. Higher values represent greater efficiency. - **Recommended benchmarks are COP ≥ 4.0 and EER ≥ 3.5.**
Return on Investment (ROI):	- Evaluates the time required to recoup renovation costs through energy savings. - **An ideal ROI ranges between 5 and 10 years, depending on the energy-saving measure implemented.**
Economic Savings on Energy Bills (%):	- Compares pre- and post-renovation energy expenses to quantify actual savings. - The goal is a 20% to 50% reduction in energy bills.
Living Comfort Indices (PMV, PPD):	- The Predicted Mean Vote (**PMV**) and the Predicted Percentage of Dissatisfied (**PPD**) measure thermal comfort as perceived by occupants. - **Optimal ranges for PMV are between -0.5 and +0.5, while PPD should be below 10%.**

Table 2: Indicators to Monitor the Success of Energy Renovation

1.3. Planning the Renovation

To identify the energy efficiency measures to be implemented and establish priorities for action, a strategy combining two complementary approaches was adopted: the development of energy audits and the use of the DREEM (**Dynamic high-Resolution dE-mand-sidE Management**) model. This software enables the simulation of consumption scenarios and proposes optimized energy efficiency interventions based on potential savings and technical-economic feasibility.

Seven Energy Efficiency Measures (EEMs) were identified for the application of the DREEM model, applicable to all pilots:

- EEM1 - Insulation of External Walls: External insulation of the main walls of the building (typically solid walls without cavities).
- EEM2 - Double-Glazed Windows: Replacement of single-glazed windows with energy-efficient double-glazed windows to reduce heat loss.
- EEM3 - Roof Insulation: Insulation between and beneath roof beams to reduce the overall heat transfer coefficient, utilizing materials with low thermal conductivity (applicable only to single-family buildings).
- EEM4 – Energy-Efficient Heating System (Gas Boiler): Replacement of an outdated heating system with a high-efficiency gas boiler.
- EEM5 – Energy-Efficient Heating System (Biomass Boiler): Replacement of an outdated heating system with a high-efficiency biomass boiler.
- EEM6 - Energy-Efficient Heating System (Heat Pump): Replacement of an outdated heating system with the installation of a high-efficiency heat pump.
- EEM7 - Energy-Efficient Lighting: Replacement of traditional lamps (fluorescent lamps) with highly efficient LED systems.

Effects of Selected Energy Efficiency Measures

For single-family buildings, the simulation indicates that replacing the existing heating system with a heat pump is the most effective measure. It reduces cumulative annual energy consumption to 10,172.8 kWh, achieving a saving of 17,758.9kWh (a 63.6% reduction compared to the baseline scenario). In terms of effectiveness, this is followed by roof insulation, which reduces consumption to 17,114.4 kWh, with annual savings of 10,816.4 kWh (a 38.7% reduction), and external wall insulation, which reduces consumption to 23,219.7 kWh, with annual savings of 4,711.1 kWh (a 16.9% reduction).

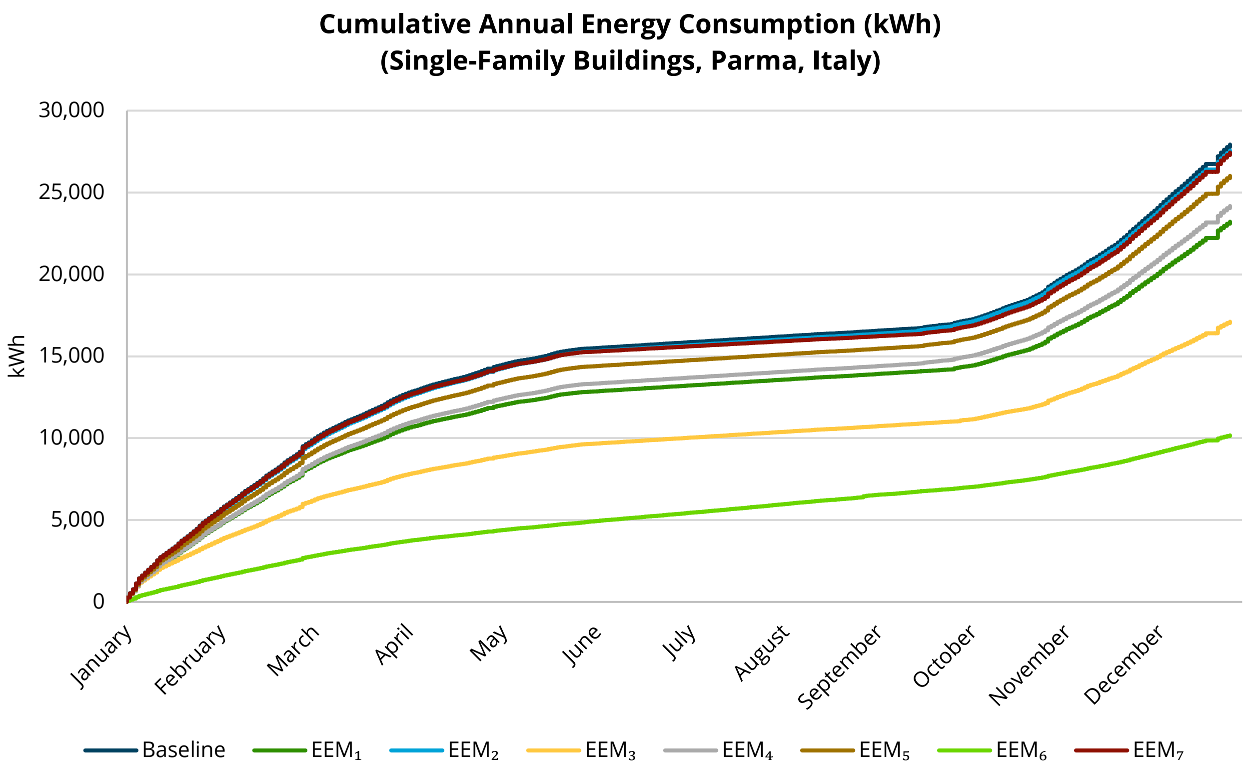


Figure 2: Cumulative Annual Energy Consumption in Parma for Single-family buildings

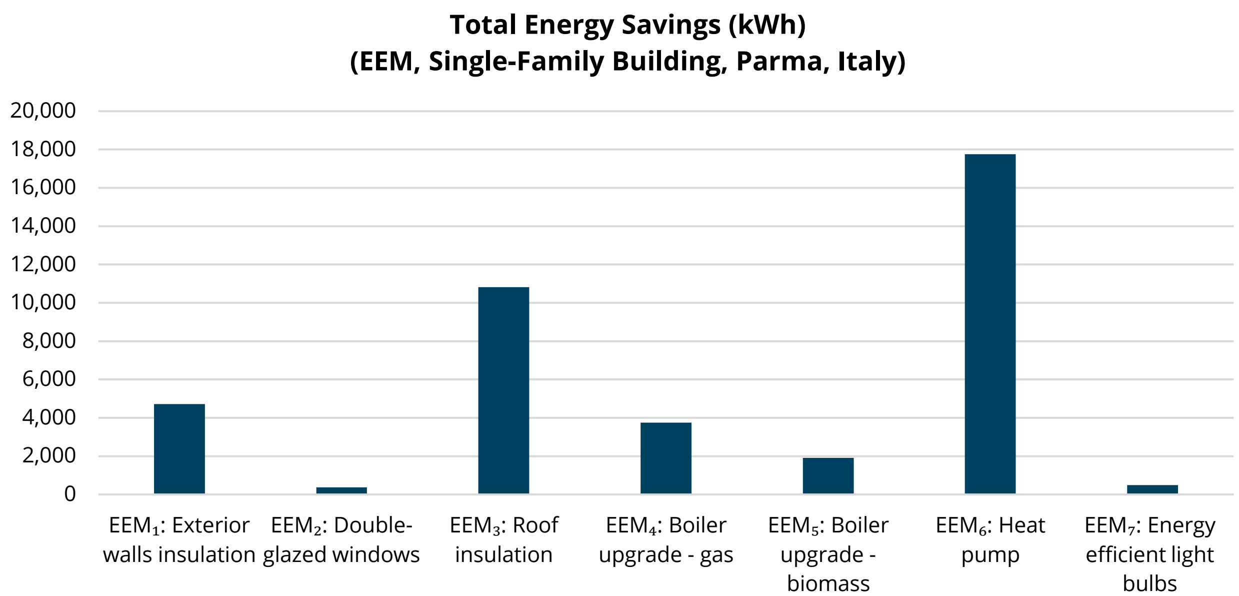


Figure 3: Total Energy Savings in Parma for Single-family buildings and each energy efficiency measures

For multi-family buildings, the simulation shows that replacing the heating system with a heat pump also yields the greatest energy savings, reducing cumulative annual consumption to 10,159.1 kWh, with a saving of 15,696.7 kWh (a 60.7% reduction). This is followed, in terms of effectiveness, by the insulation of external walls, which reduces annual consumption to

17,432.6 kWh, with a saving of 8,426.2 kWh (a 32.6% reduction), and the installation of an enhanced gas boiler, which reduces annual consumption to 22,179.9 kWh, with a saving of 3,675.8 kWh (a 14.2% reduction).

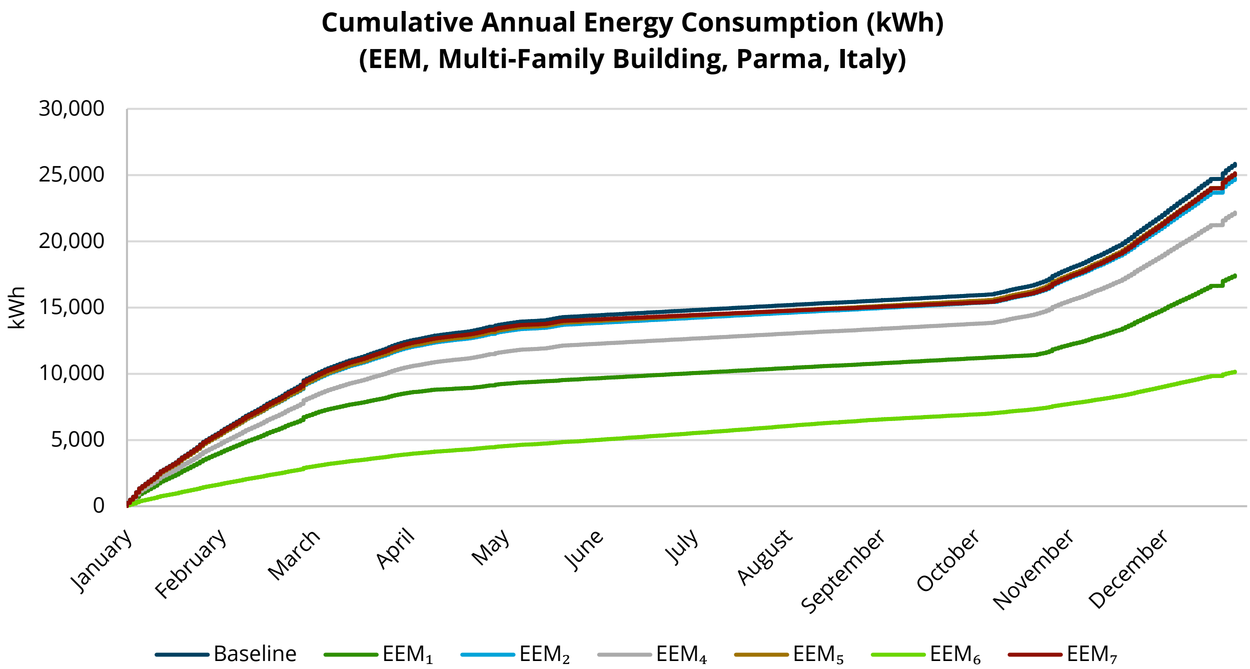


Figure 4: Cumulative Annual Energy Consumption in Parma for Multi-family buildings

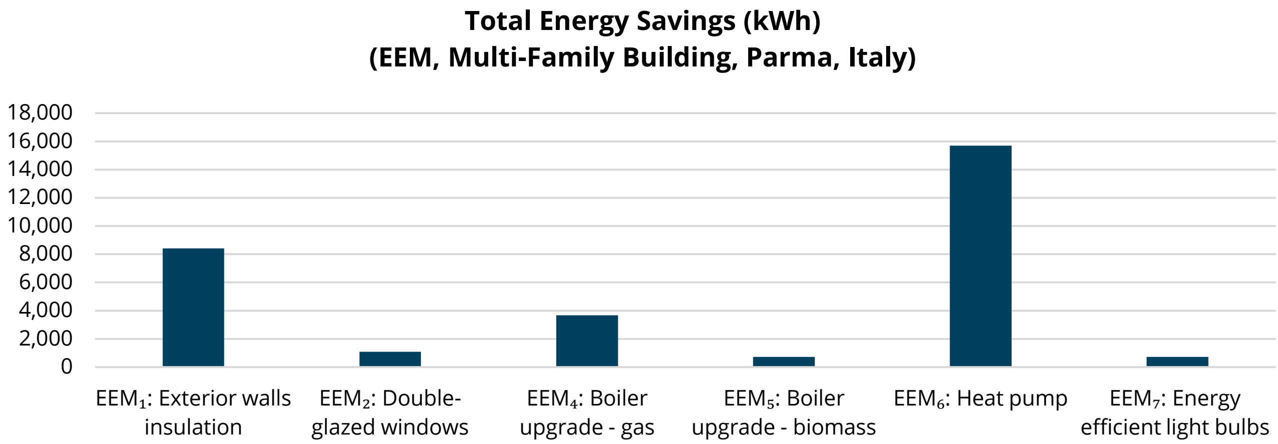


Figure 5: Total Energy Savings in Parma for Multi-family buildings and each energy efficiency measures

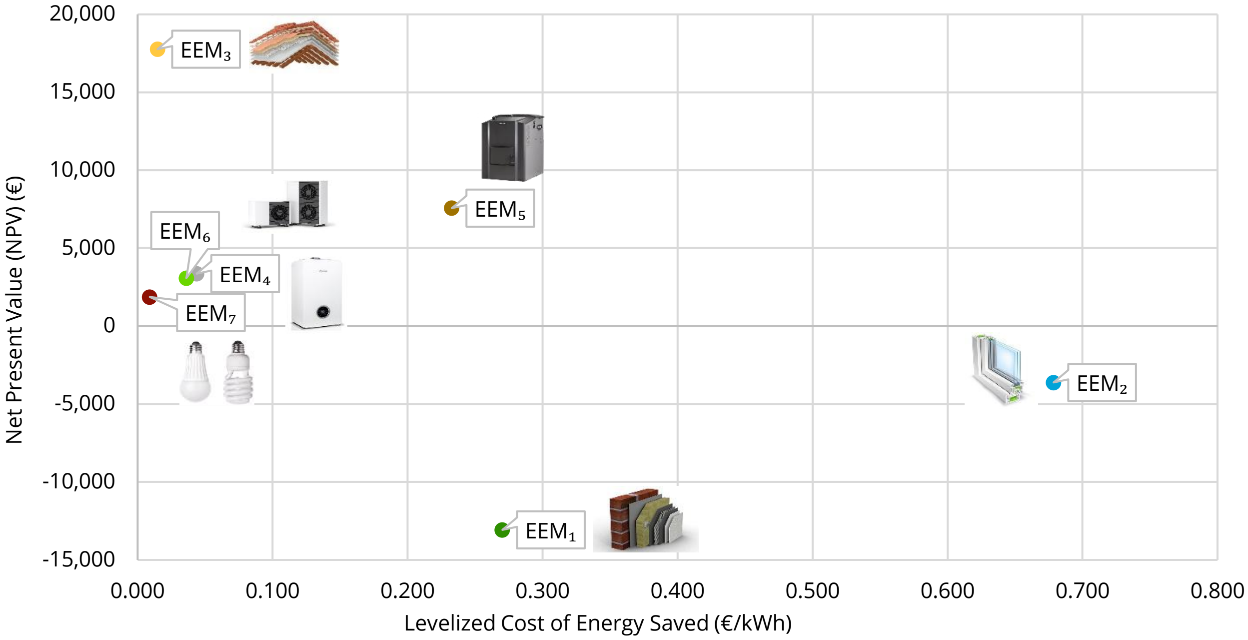
Economic Benefits and Return on Investment

This section outlines the indicators used to highlight the economic benefits of each energy efficiency measure. The key indicators considered are:

1) Investment Costs (€): Represents the total expenditure required to implement a specific project or intervention, including initial costs for materials, labour, installation, and other related expenses.
2) Useful Life (Years): Estimates the period during which the investment or installation (e.g., heating or thermal insulation system) remains effective and functional before requiring significant repairs or replacements.
3) Discount Rate (%): The percentage used to discount future cash flows, calculating the present value of anticipated savings or earnings while accounting for inflation and the cost of capital or expected return rate.
4) Net Present Value (NPV) (€): The difference between the present value of future cash flows generated by the investment and its initial cost. A positive NPV indicates a profitable investment, serving as a critical indicator for evaluating a project's cost-effectiveness.
5) Payback Period (Years): The time required to recover the initial investment through the savings or benefits generated. This reflects how many years it takes for economic returns to offset costs.
6) Levelized Cost of Energy Saved (LCSE): Measures the cost per kWh of energy saved, calculated by dividing the total investment cost by the energy saved over the useful life of the intervention. This facilitates comparison of the economic efficiency of different measures.

Single-Family Buildings

According to the DREEM model, developed by the University of Piraeus Research Centre (UPRC), the measures with the best NPV performance for single-family buildings are roof insulation and biomass boiler upgrades, with NPVs of €17,765.9 and €7,568.6, respectively. Conversely, external wall insulation and replacing windows with double-glazed alternatives yield negative NPVs, making these interventions unprofitable without subsidies. The most cost-effective measures, in terms of LCSE, are energy-efficient light bulbs and roof insulation, with LCSEs of €0.009/kWh and €0.015/kWh, respectively. These measures also have the shortest payback periods, at 0.4 and 2.4 years, respectively.



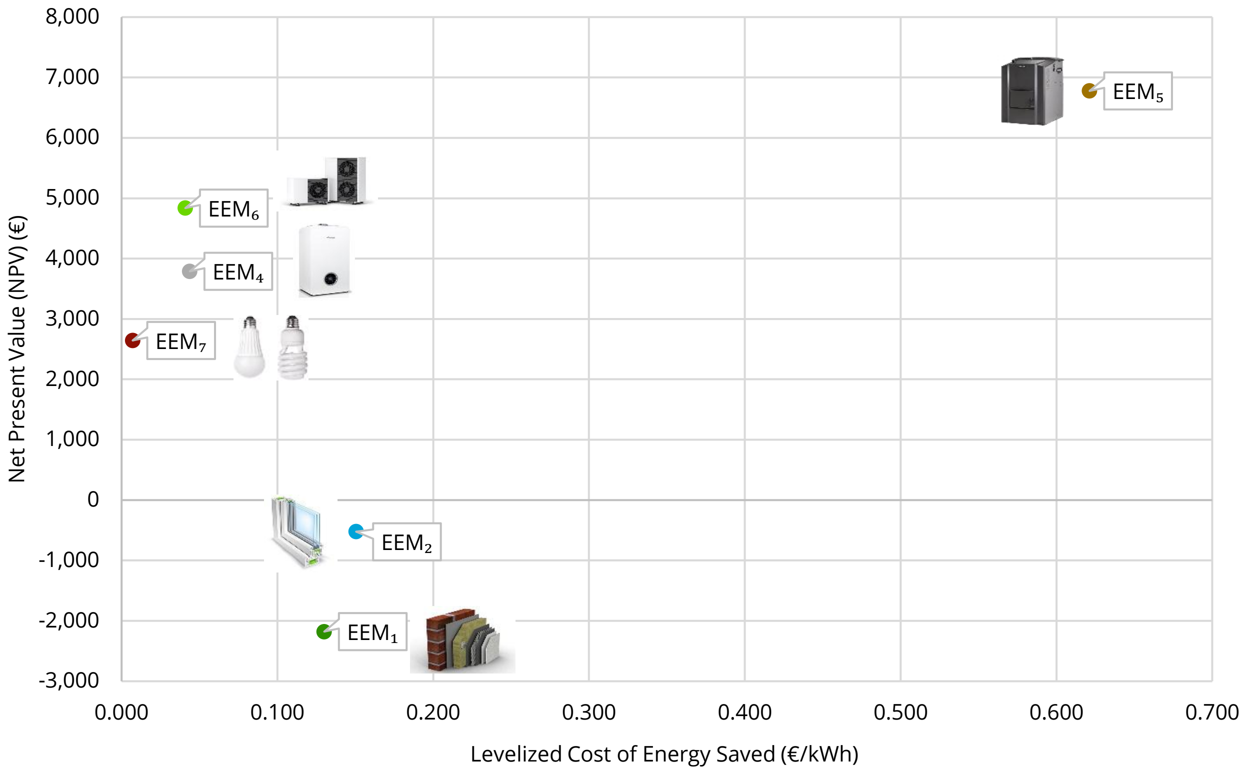
The table below outlines investment costs, useful life, discount rate, NPV, payback period and levelized cost of energy saved (LCSE) for single-family buildings, in the absence of subsidies.

Energy Efficiency Measure	Investment Costs (€)	Useful Life (Years)	Discount Rate (%)	NPV (€)	Payback Period (Years)	Levelized Cost of Energy Saved (€/kWh)
EEM1: Insulation of External Walls	22,013	30	4.00%	-13,072.3	>Lifetime	0.270
EEM2: Double-Glazed Windows	4,313	30	4.00%	-3,615.0	>Lifetime	0.679
EEM3: Roof Insulation	2,762	30	4.00%	17,765.9	2.5	0.015
EEM4: Gas Boiler Upgrade	735	20	4.00%	3,364.8	2.6	0.044
EEM5: Biomass Boiler Upgrade	3,500	20	4.00%	7,568.6	4.8	0.233
EEM6: Heat Pump	6,000	20	4.00%	3,078.9	11.4	0.036
EEM7: Energy-Efficient Light Bulbs	60	23	4.00%	1,871.6	0.4	0.009

Table 3: Table reporting energy efficiency measure and respective Investment Costs, Useful Life, Discount Rate, NPV, Payback Period, Levelized Cosy of Energy Saved for Single-family buildings

Multi-Family Buildings

For multi-family buildings, upgrading the biomass boiler and installing a heat pump deliver the highest NPV, with values of €6,777.5 and €4,836.3, respectively. Regarding LCSE, energy-efficient light bulbs and heat pumps provide the best results, at €0.007/kWh and €0.041/kWh, respectively. The shortest payback periods are observed for energy-efficient light bulbs and gas boilers upgrades, at 0.4 and 2.5 years, respectively. However, measures like external wall insulation and replacing windows with double-glazing are not economically viable without subsidies, as they exhibit negative NPVs.



The table below outlines investment costs, useful life, discount rate, NPV, payback period and LCSE for multi-family buildings, in the absence of subsidies.

Energy Efficiency Measure	Investment Costs (€)	Useful Life (Years)	Discount Rate (%)	NPV (€)	Payback Period (Years)	Levelized Cost of Energy Saved (€/kWh)
EEM1: Insulation of External Walls	18,943	30	4.00%	-2,177.8	>Lifetime	0.130
EEM2: Double-Glazed Windows	2,200	30	4.00%	-552.2	>Lifetime	0.151
EEM4: Gas Boiler Upgrade	735	20	4.00%	3,789.5	2.5	0.044
EEM5: Biomass Boiler Upgrade	3,500	20	4.00%	6,777.5	5.2	0.621
EEM6: Heat Pump	6,000	20	4.00%	4,836.3	9.1	0.041
EEM7: Energy-Efficient Light Bulbs	75	23	4.00%	2,643.9	0.4	0.007

Table 4: Table reporting energy efficiency measure and respective Investment Costs, Useful Life, Discount Rate, NPV, Payback Period, Levelized Cosy of Energy Saved for Multi-family buildings

Expeditious Audit Results

The analysis of the most common building types in the rural area of Valtaro and the efficiency measures suggested by the expeditious audits has led to the identification of the following intervention guidelines:

- Insulation of Vertical Opaque Envelopes (Walls): These interventions are often challenging due to high costs, long payback periods, and the aesthetic characteristics of many rural buildings, such as exposed stone walls. In such cases, less invasive and more cost-effective solutions are recommended, such as insulating floors adjoining attics (using insulating mats) or cellars, after verifying regulatory height requirements. These measures, while requiring lower investments, can reduce heat loss and achieve energy savings of 10-20%.
  For condominium buildings constructed between the 1960s and 1980s, characterized by poor thermal insulation, reinforced concrete frames, perforated or semi-solid brick walls, brick and concrete floors, and single-glazed aluminium or wooden windows, external insulation is a preferable solution. These buildings typically have high energy consumption (>180 kWh/m^2) and are generally not subject to landscape or technical constraints. In such cases, external wall insulation can be more cost-effective, as fixed costs (e.g., scaffolding and design) can be divided among multiple owners.
- Replacement of Windows and Doors: While this intervention involves significant initial costs and long payback periods, it offers benefits in terms of energy savings (5-10%) and improvements in safety and living comfort.
- Installation of Renewable Energy Sources and Efficient Heating Systems: The adoption of renewable energy sources, such as heat pumps combined with photovoltaic systems, is

encouraged under the Energy Performance of Buildings Directive (EPBD, called “Green Homes”), approved in March 2024. This directive aims to progressively reduce greenhouse gas emissions and energy consumption in the building sector by 2030 and achieve climate neutrality by 2050. These solutions are applicable even in rural settings but involve significant investments and are most efficient in well-insulated buildings (insulated envelope). Otherwise, hybrid systems, such as gas or LPG condensing boilers integrated with - or entirely replaced by – new-generation biomass systems, are more advantageous. Biomass systems can achieve savings of 15-30% and shorter payback times, especially when combined with local supply chains and incentives such as the Thermal Account (“Conto Termico”) or regional subsidies in Emilia-Romagna.

- Building Automation Systems: Advanced technologies can transform buildings into "smart buildings" through the use of sensors, platforms, and integrated control systems. These systems adjust indoor air conditioning based on outdoor temperatures, manage lighting and appliances according to occupant needs, improve living comfort by regulating air quality and adjust shading systems (e.g., blinds or shutters) according to natural light. They also enhance safety by monitoring for fires and alarms. Implementation costs are relatively low, with short payback times and potential energy savings of up to 30% using advanced systems.

Timing of the Works

The time required to complete energy renovation interventions and achieve one or more energy class upgrades depends on the complexity of the work, bureaucratic processes, and the availability of contractors. General timelines are as follows:

- Design and Inspection (*1-3 months*): A qualified technician conducts an inspection to perform the energy diagnosis and develop the renovation project.
- Obtaining Permits and Funding (*1-6 months*): The duration depends on securing the necessary permits (e.g., SCIA or CILA) and, if applicable, on the approval of incentives and financing.
- Execution of the Works (*3-12 months*): Timing varies based on the complexity of the interventions. Simple measures, such as replacing fixtures or installing photovoltaic systems, require only a few months, whereas more extensive projects, such as wall insulation or heating system replacement, may take longer.
- Final Energy Certification (*1-2 weeks*): Once the work is completed, a qualified technician drafts a new Energy Performance Certificate (EPC) to certify the building's improved energy class.

In total, the process may take 6 months to 1.5 years, with potential delays due to bureaucracy, material shortages, and/or labour availability. Based on the audits conducted, the average cost of the efficiency measures included in the certificates is approximately €29,500 per property unit, with a range between €13,000 and €52,000, depending on the size of the property and the interventions required.

Funding Currently Available

At the time of writing, the main financing options available for energy renovation projects are tax deductions, including:

- **Superbonus**: 70% deduction, valid until December 31, 2024, for condominiums and multi-family buildings.
- **Ecobonus**: Deduction of 50-65%, depending on the type of intervention (e.g., thermal insulation, replacement of fixtures), valid until December 31, 2024.
- **Renovation Bonus**: 50% deduction on a maximum of €96,000, valid until December 31, 2024.
- **Sismabonus**: Deduction of 50-85%, depending on the reduction in seismic risk, valid until December 31, 2024.
- **Furniture and Appliances Bonus**: 50% deduction on the purchase of furniture and large appliances up to €8,000, valid until 2024.
- **Green Bonus**: 36% deduction for garden and terrace interventions, with a maximum of €5,000, valid until December 31, 2024.
- **Bonus for the Removal of Architectural Barriers**: 75% deduction for installing lifts, stairlifts and ramps, valid until December 31, 2025.

The methods for utilizing tax deductions include direct deductions, credit assignment, and invoice discounts. Direct deductions are applied directly to personal taxes, allowing taxpayers to offset a portion of their expenses against their tax liability. Credit assignment involves transferring tax credits to third parties, such as banks or companies, to gain liquidity or immediate discounts on the costs of interventions. Lastly, the invoice discount method allows suppliers to apply an immediate discount on the price of the work, with the supplier subsequently recovering the tax credit. However, these options may not be accessible to low-income households or those experiencing energy poverty due to a lack of initial capital.

Looking ahead, it remains unclear what financing options will be available in 2025. The National Recovery and Resilience Plan (PNRR), supplemented by the RePowerEU chapter, and the Integrated National Energy and Climate Plan (PNIEC) outline initiatives aimed at combating energy poverty, reducing emissions, and promoting energy upgrades to the building stock. New financial measures to support these objectives are anticipated.

At present, European cohesion policy funds do not finance private residential building renovations in the region. However, several Italian banks offer specific financial products, such as loans and mortgages with favourable conditions, to facilitate energy renovation interventions.

These financial products support projects like installing photovoltaic systems, insulating walls, replacing windows, and adopting more efficient heating systems.

Risks and Disturbances Arising from the Work

Renovation projects can present various technical, economic and environmental risks that may jeopardize their success. Technical risks include inadequate initial energy analyses, which may result in interventions that fail to address the actual needs of the building, rendering them ineffective; for example, the analysis assumes that existing windows are in good condition and with efficient seals, which means that significant thermal losses are not taken into account. To mitigate this risk, you must perform a comprehensive energy audit by certified professionals, including thermal imaging, blower door tests, and detailed energy simulations. Compatibility between the interventions and the building structure is another critical factor; for example, thermal insulation solutions may need to be tailored to specific materials or configurations. To be more specific, the application of a thermal insulation system on porous brick walls or on historic buildings with decorative plasterwork can lead to plaster detachment or compromise the transpiration of the structure. To mitigate this risk, you may take in consideration the possibility to conduct a structural assessment and material analysis before finalizing the design. Opt for tailored solutions such as breathable insulation for historical buildings or lightweight panels for fragile structures.

Design or installation errors can further undermine the effectiveness of measures, potentially causing structural damage such as leaks or ventilation issues. The use of poor-quality materials or insufficient integration of energy systems may also reduce the overall effectiveness of the interventions. To mitigate all those risks it's better to engage experienced, certified contractors and require detailed execution plans, and also specify high-quality, certified materials in contracts, by using suppliers with proven track records and request product warranties.

From an economic perspective, unexpected costs can arise during the works, often due to undetected structural problems or bureaucratic delays in securing funding or tax incentives. To mitigate this risk, it's better to include a contingency budget of at least 10-15% in financial planning. Regulatory uncertainty, as demonstrated by the case of the Superbonus, can disrupt financial planning and exert additional pressure on costs. On the environmental front, improper waste management or the presence of hazardous materials such as asbestos can pose significant challenges. To mitigate those risks, it's better to conduct an environmental assessment before starting works, and also hire certified removal specialists if required and follow strict containment and disposal protocols.

The renovation works can also cause physical and psychological discomfort for residents and neighbours. Noise is one of the most common disturbances, but it can be mitigated by scheduling noisier tasks during specific hours, avoiding early mornings or evenings, and temporarily isolating in quieter areas. Earplugs or noise-cancelling headphones can also help.

Dust and dirt generated by the work can be minimized by sealing affected areas with plastic sheeting or panels, using air purifiers to keep adjacent areas clean, and scheduling regular cleaning. Moreover, chemicals from materials used may emit strong smells or toxic fumes, which can be managed through proper ventilation and the use of eco-friendly, solvent-free materials.

Reduction of living space is another challenge, particularly if the work involves critical areas of the house like the kitchen or bathroom. In such cases, reorganizing living spaces and using temporary storage for bulky items may help. Planning the work in phases can ensure that not all areas are inaccessible at the same time, while temporary solutions, such as makeshift kitchens or emergency bathrooms, can reduce inconvenience. Interruptions to essential services such as electricity, water, or gas can also be disruptive. These can be mitigated by planning for outages, conserving water, preparing meals in advance, or renting equipment like electric generators or water tanks if necessary.

Stress caused by delays, unforeseen expenses, or challenges in managing timelines should not be underestimated. Detailed planning, a realistic budget, a clear schedule, and regular communication with professionals can help minimize project-related anxiety. Engaging a general contractor to supervise the work is another effective strategy. Additionally, including financial and time buffers can help address unexpected issues. Monitoring expenses regularly and maintaining open communication with suppliers can prevent surprises and ensure effective budget control.

Finally, renovation projects may also strain family or neighbourly relationships. Noise and prolonged inconveniences can create tensions, but transparent communication with neighbours, including advance notice about the work and agreeing on suitable schedules, can help maintain good relations. Listening to complaints and finding shared solutions is essential to avoid conflicts.

In conclusion, undertaking energy renovation projects requires not only careful planning and effective management of spaces, time, and costs but also a strong focus on engaging homeowners. By actively listening to their visions, addressing their concerns, and ensuring they feel genuinely heard throughout the process, disruptions can be minimized. This inclusive approach fosters a sense of collaboration and trust, paving the way for the successful and satisfying completion of the works with greater peace of mind for everyone involved.

1.4. Identify and Overcome Barriers and Challenges

The energy renovation of buildings in Italy faces numerous barriers that require targeted strategies for resolution. Among the primary obstacles are:

Economic Barriers:

The high costs associated with interventions such as thermal insulation, window replacement, or the installation of efficient energy systems often make energy upgrades inaccessible, especially for families with limited financial resources. In these cases, government incentives such as tax deductions or building bonuses are crucial, although they are often difficult for economically disadvantaged families to access. Long-term financial tools, such as subsidized mortgages, can provide a solution by allowing investments to be spread over time, thereby reducing the immediate financial impact. Several financial institutions offer products to support such interventions:

- Banco BPM provides green loans at subsidized rates for interventions like solar panel installation or improving thermal insulation.
- BPER Banca offers the "Green Mortgage" (Mutuo Green), which covers a wide range of energy efficiency interventions.
- Crédit Agricole provides green loans and mortgages to improve home energy efficiency, supporting various interventions aimed at reducing energy consumption.
- UniCredit offers green financing for energy efficiency measures, including efficient heating systems or building insulation, with tailored financial solutions for families and condominiums.
- Intesa Sanpaolo has multiple subsidized-rate products specifically designed for energy renovation interventions.
- BNL promotes green loans and financing under favourable terms for energy efficiency interventions, such as installing low-consumption systems or optimizing thermal insulation.

State guarantee funds, such as the "Guarantee Fund for the Purchase and Renovation of the First Home", represents another valuable resource. This fund guarantees up to 50% of a mortgage (to a maximum of €250,000) for all applicants, regardless of age, while providing reduced rates for specific groups such as young couples (at least one member under 35 years of age), young people under the age of 35 with an atypical employment relationship, single-parent families with minors, and tenants of public housing (owned by IACPs). Applications must be submitted directly to participating banks using official forms available on the websites of CONSAP Spa, the Department of the Treasury, and the banks involved.

For individuals in energy poverty, additional tools exist, such as support from third-sector organizations like Banco Energia and Centoperuno Odv, or microcredit services offered by associations like RICREDITI. Energy Service Companies (ESCos) also present an attractive option, enabling property owners to undertake renovation projects without bearing the full upfront cost, as payments are made using the energy savings achieved (e.g., https://escosolution.it/ Faenza; https://www.escoagroenergetica.it/ Rome).

Information Barriers:

Many property owners lack adequate information about energy-saving opportunities, available technologies, or existing tax incentives. Awareness campaigns highlighting the economic and environmental benefits of energy efficiency are essential. These awareness campaigns can also serve to inform the citizen about where to go for support, such as the ENEA (Italian National Agency for New Technologies, Energy and Sustainable Economic Development) website, which offers comprehensive resources on energy-saving technologies, best practices, and current tax incentives. Also, they provide publications, guidelines, and tools to assist property owners in making informed decisions about energy efficiency improvements. Tools such as free training courses, like those offered under the RENOVERTY project via the AISFOR Academy platform, and low-cost energy consultancy or audit services, can provide valuable guidance to property owners during the decision-making process.

Administrative Barriers:

Bureaucratic procedures for obtaining permits, particularly for historic buildings or buildings subject to preservation constraints, are a significant deterrent. Simplifying regulations and establishing one-stop shops for permit management can streamline the authorization process. At present, only one OSS is available in the Parma area, the Sportello Energia&Condomini managed by ATES Parma, which offers free services to citizens such as inspections with a thermal imaging camera to check heat dispersion and support to find out how to finance energy renovation.

Disagreements in Condominiums:

Conflicts among residents and a lack of interest often slow down the decision-making process for initiating renovation projects in apartment buildings. Generally, the majority required for the approval of works is 50% plus one of the votes of the condominiums present at the meeting. In some cases, a qualified majority of 66% or 75% may be required. Informational meetings with experts can help clarify the economic and living benefits of these interventions, fostering consensus.

Return on Investment:

The long payback periods of investments serve as another disincentive. Flexible financing solutions that allow interventions to be covered through energy savings over time, or incentives that shorten the payback period, could motivate more property owners to undertake these works. Another way is to pool resources with other property owners, to form or join energy communities which can create economies of scale, lowering the costs of installation and maintenance.

Shortage of Technical Skills:

A lack of up-to-date technical expertise among professionals can compromise the quality of interventions. Investing in continuous professional training is essential to ensure the correct implementation of advanced technologies and compliance with current regulations. To rely on thrustworthy and capable companies and professionals, in addition to word of mouth from family and friends, you can consult the dedicated section of the Sportello Energia&Condomini.

All these issues and possible actions to mitigate them were validated during workshops organised within the project. Furthermore, during one of this workshop, property owners who had participated in energy audits shared their direct experiences, highlighting both positive and negative aspects. Among the main challenges reported were the high costs of interventions, the complexity of administrative procedures, and a limited understanding of long-term benefits. In many cases, particularly among elderly owners or when there is disinterest from their children, the focus remains solely on immediate costs, leading to a reluctance to undertake interventions without considering future advantages.

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Co-funded by the European Union under project ID 101077272. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.