18 Assessing Energy Poverty and Potential Retrofit Scenarios in Residential Stock in Tirana, Albania

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18.1 Introduction

Rapid and unplanned urbanization of cities has projected harmful consequences The city structure has changed informally regarding urban form, building construction and materials (Pee & Pan, 2022). Due to these developments, energy poverty (EP) is considered one of the most significant challenges, requiring immediate attention on a global scale energy poverty by increasing the impact on the well-being of people and the environment (Middlemiss et al., 2019; Sareen et al., 2020; Simcock et al., 2021).

It encompasses households' inability to use the necessary energy services for thermal comfort, cooking, or illumination (Ortiz et al., 2021). Numerous definitions of EP exist, all attributed to its complexity and multi-dimensionality. Bouzarovski (2013) defined it as difficulties accessing or affording adequate domestic energy services (space heating, cooling, etc.) due to financial, regulatory, or technical constraints.

"Lived experience energy poverty" refers to the subjective experience of individuals or households who are unable to afford adequate heating, cooling, or lighting in their homes, leading to discomfort, health issues, and reduced quality of life. It encompasses the social, economic, and environmental factors that contribute to a person's inability to access or afford energy services, such as low-income, high-energy prices, poor housing quality, and limited access to energy-efficient technologies (Bell & Lane, 2018). This term emphasizes the importance of understanding energy poverty from the perspective of those who are directly impacted by it and highlights the need for solutions that address the unique challenges faced by vulnerable communities (Bouzarovski & Petrova, 2015).

Research on energy poverty has increasingly recognized the importance of the lived experience perspective and has used various qualitative methods such as interviews, focus groups, and ethnography to explore the subjective dimensions of energy poverty (Bell & Lane, 2018; Bouzarovski & Petrova, 2015). This approach has highlighted the diversity of experiences and coping strategies among energy-poor households and the social and cultural factors that shape these experiences (Bouzarovski et al., 2012). According to Boardman (2012), a household suffers from energy poverty if it needs to spend more than 10% of its income on total fuel. By this definition, the concept of energy poverty expands in dimension, encompassing more than the economic capability of "low-income households" (Llera-Sastresa et al., 2017; Zhang et al., 2021). Many researchers have studied Energy Poverty in respective European states, providing a valuable guideline to follow. Papada and Kaliampakos (2016) assessed the significant vulnerability of Greek households to energy poverty in the middle of a severe economic crisis. The findings showed that 58% of Greek households are energy poor, and among families under the poverty threshold, the energy poverty rate exceeds 90%. Karásek and Pojar (2018) conclude

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that household expenditures on energy consumption had recently increased, and the number of households in energy poverty had reached 16% in the Czech Republic.

A practical approach to reducing energy poverty has proven to be the retrofit methods applied to households suffering from this problem. In a study conducted by Ardente et al. (2011), it was indicated that the most significant benefits of energy consumption reduction were the improvements in envelope thermal insulations, lighting, and glazing. Omar et al. (2015) concluded that retrofitting techniques in the envelope could reduce energy consumption by up to 28%. Reducing energy consumption in the building sector is essential for achieving sustainability goals and mitigating the impacts of climate change. However, achieving energy efficiency goals should not come at the expense of human comfort and building identity. It is critical to develop climate and intervention strategies that consider the unique characteristics of each building and the needs of its occupants (Dervishi & Mahdavi, 2013a, 2013b; Mahdavi & Dervishi, 2011a, 2011b). One approach to reducing energy consumption in buildings is through passive design strategies, which prioritize using natural light, ventilation, and insulation to reduce energy demand for heating and cooling. Passive design can be integrated into retrofits of existing buildings, resulting in significant energy savings while maintaining or enhancing indoor comfort (Dervishi & Mahdavi, 2013a, 2013b; Mahdavi & Dervishi, 2013).

On the other hand, the accurate calculation of irradiance values on various surfaces is crucial in simulation applications, and it depends heavily on the sky models used in different climatic conditions. Numerous studies have addressed this issue, emphasizing the importance of using appropriate sky models to improve the accuracy of simulations (Dervishi & Mahdavi, 2012, 2013a, 2013b; Mahdavi & Dervishi, 2010, 2011a, 2011b; Mahdavi et al., 2009; Orehounig et al., 2014). For instance, Reinhart and Perez (2004) proposed a simplified Perez sky model for solar radiation simulations suitable for locations with cloudless or partially cloudy skies. Similarly, Haberl et al. (2014) developed a new sky model based on the statistical analysis of high-resolution sky images that can be used for solar energy system simulations in any location worldwide. Kummert and Lhomme (1996) suggested an isotropic sky model that considers the hemispherical distribution of solar radiation. This was more accurate than other traditional sky models for buildings in northern latitudes.

A review of the literature shows how various researchers have explored retrofitting historic buildings, especially in Europe. Several theories have been proposed in this field, some focusing on possible interventions to reduce energy consumption (Ardente, 2011) and others on the importance of traditional buildings' historical values (Bao et al., 2018; De Feo & Brano, 2021). Preserving traditional buildings not only contributes to the cultural heritage of a region but also has economic, social, and environmental benefits. These buildings often have unique architectural features reflecting local culture and history. By preserving them, we can maintain the historical identity of a region and promote tourism, which in turn can boost local economies (Padeiro et al., 2018).

Several studies have investigated energy poverty, energy and thermal performance, and potential scenarios in buildings in Albania, but limited research has utilized comprehensive building simulation models to address these issues (Dervishi et al., 2012; Göçer & Dervishi, 2015; Picari & Dervishi, 2019). Dervishi et al. (2022) studied the thermal performance of traditional residential buildings constructed in Albania between the 16th and 19th centuries. Retrofitting the building fabric improved energy performance by up to 46.3% and thermal comfort by up to 7.2°C, with a payback period of 7.9 years. Similarly, Belba and Dervishi (2018) analysed the thermal performance of five traditional housing buildings in the Kukes region. They found that insulation improvements in building fabrics could reduce annual energy consumption by up to 35%. Resuli and Dervishi (2015) used a combination of questionnaires and computational simulations to explore the energy performance of Italian Houses in Tirana and propose possible retrofit interventions. Specifically, a specific combination of improvement measures could significantly reduce the annual heating energy by up to 30%.

On the other side, the energy performance simulation has been studied in other building typologies. Dervishi and Karamani (2020) explored the energy performance and thermal comfort conditions of an existing industrial building in Durres, Albania. The study analyses the building envelope retrofitting via building performance simulation. The results suggest that improvements and insulations in building fabrics and ventilation regimes could reduce the annual energy consumption by up to 19% and the monthly summer temperature by up to 1.5°C. Breçani et al. (2019) studied the simulation-assisted energy performance and thermal comfort conditions of selected agricultural structures and alternative thermal retrofit measures in three climatic regions in Albania. The alternative scenarios incorporate thermal insulation of the walls and a change in building geometry. The results suggest that changes in building morphology could reduce annual energy consumption by up to 25%. Breçani and Dervishi (2019) studied the thermal performance of bunkers in Albania via detailed computational simulations and possible retrofitting scenarios. The results show that insulation does not affect the heat flux through the outer walls. Furthermore, the results establish that the same building consumes 44–145% more energy when located above ground instead of underground. Bano and Dervishi (2021) evaluate the greenery's effectiveness in reducing energy loads and improving indoor thermal comfort. Several design variables, including WWR (window-to-wall ratio), LAI (leaf area index), and plant height, are selected for a comprehensive whole-building energy performance analysis. The impact of vertical greenery effectiveness on a fully glazed building scenario considerably reduces 4.7°C indoor temperature and 9°C radiant temperature in the summer, ranging from 14% up to 34% energy savings. Kalaci and Dervishi (2014) focus on the adaptive reuse of a historical housing building and examine the challenges in incorporating a sustainability framework into the adaptive reuse of the building, viewed more holistically, integrating social, economic, environmental, and urban political policies.

The literature review analysed highlights the importance of energy poverty and energy retrofitting, especially in Albania. This research can provide an original contribution addressed by the following knowledge gaps in the literature and identify potential areas for further improvement in simulation.

- Limited studies have applied a detailed building simulation model based on comprehensive onsite input (energy bills, questionnaires, temperature and humidity data loggers, building, HVAC, occupancy and ventilation schedules, and cost estimation) in the housing sector in Albania.
- Limited studies have assisted in comparing and evaluating the thermal and energy performance of housing typologies located in Mediterranean climates, highlighting the differentiation of performance and needs for each typology.

Therefore, the study's main objective is to evaluate energy poverty in Tirana, Albania, and develop potential energy retrofit scenarios to improve energy performance. The chapter aims to develop a comprehensive methodology based on an analytical and quantitative approach that would significantly contribute to the energy retrofitting field in the Mediterranean region within the case study of Albania. Specifically, the present study explores comprehensive research on the prevalence of energy poverty in housing stock in Tirana, highlighting the vulnerability of households and providing potential passive retrofitting measures for its eradication. The long-term goal of this research is to analyse existing energy efficiency in buildings and develop a simulation-based retrofitting scheme for these buildings.

18.2 The Albanian context

18.2.1 Prevalence of energy poverty

Albania is subject to the constant challenges of urban development and those presented by continuous economic, socio-cultural, and environmental transformation. Focusing on the development during these past 30 years, a radical change in society's socio-cultural and lifestyle models is noticed. This new model is developed on the existing environment and infrastructure, which need to be improved (Pojani, 2010). Most of the available residential stock needs to respond to contemporary building criteria, thus providing a higher quality of life. More than half of the existing building stock in Albania was built between 1945 and 1990, which corresponds to 83.7% of the residential stock (Triantis, 2018). During this period, the government initiated a massive construction programme to meet the growing demand for housing. Most of the housing stock built during this period consisted of buildings designed and built quickly and inexpensively to meet the pressing housing needs with low thermal efficiency. As a result, many need to be better insulated and equipped with efficient heating systems, leading to high energy consumption and waste. According to a report published by the World Bank (Review, 2021) that categorizes countries based on their GNI (gross national income) and GDP (gross domestic product), Albania is ranked as an "upper middle income" country in the GNI list. However, Albania is ranked 40th out of 49 countries on the GDP list.

The primary household energy source is electricity (45%), followed by biomass (38%). Furthermore, Albania has a high unemployment rate of 19%, which is continuously growing. Many households face difficulties in paying the bills and need more heating to reach thermal comfort (Instat, 2023), resulting in the high severity and prevalence of insufficient access to energy services in Albania. Although far from attention, according to studies being performed, Albanian households will be even further endangered by energy poverty, caused by a lack of available government funding to implement beneficial monetary policies for the householders (Mustafaraj, 2014). From a long-term perspective, it is essential to ensure that buildings constructed after 1991 are retrofitted, as they will be responsible for around 43% of the final energy consumption in the sector (Taipi & Ballkoci, 2017).

On the other side, recently, Albania's Ministry of Infrastructure and Energy compiled two national laws regulating energy efficiency and buildings' energy performance. Law no. 124/2015, "Energy Efficiency," (2015) outlining the measures that must be taken to improve energy efficiency across the country, focusing on industry, transportation, and public buildings. Law no. 116/2016, "Energy Performance of Buildings," (2016) sets minimum energy performance standards for new and existing buildings and requires building owners to obtain an energy performance certificate. These laws aim to ensure that Albania complies with Directive 2010/31/EU (2010) by promoting renewable energy sources, reducing energy consumption, and improving the energy efficiency of buildings.

18.3 Methodology

18.3.1 Overview

The research methodology implemented for studying housing typologies in Tirana involves five distinct stages. The first stage is focused on identifying a representative group of housing typologies for the city, with a specific emphasis on those that are more prevalent and relevant for the study. The chosen typologies include Prefabricated Buildings (PRT), Silicate Brick Buildings

(SBT), and Informal House Units (INT). In Section 3.3, detailed information on the construction time, typology, geometry, and window-to-wall ratio (WWR) is collected during this stage, while in Section 3.4, a questionnaire is administered to the residents of the selected buildings. This questionnaire is designed to gather information about several aspects of their living conditions, such as the temperature comfort in their houses, the type of heating and cooling systems used, their annual electricity bills, and how their economic situation influences their heating and cooling habits.

In the third stage, simulation models are developed to collect data on local climate, occupancy, and heating and cooling schedules for one or more representative buildings from each typology. The models are then calibrated by comparing their results with actual bills obtained in the previous stage to establish a baseline for assessing the impact, need, and potential for reducing energy demand in the buildings. The fourth stage involves exploring different retrofitting scenarios to improve the sustainability of residential buildings. The selected buildings and retrofitting scenarios are evaluated based on indoor thermal comfort, energy demand reduction, and overall financial profitability for the homeowners. Finally, the fifth stage involves analysing the study results and developing recommendations based on the findings. These recommendations may include guidelines for design and construction standards as well as energy efficiency measures to improve the energy performance of the studied housing typologies in Tirana.

18.3.2 Climate

The climate of Tirana, defined by the Köppen climate classification like Cfa, is Mediterranean, with mild, rainy winters and hot, sunny summers. The average precipitation is about 1,266 millimetres per year. The city receives the most rainfall in the winter, from November to March, and less in the summer, from June to September. Springs and summers are hot, reaching over 20°C from May to September. Temperatures vary throughout the year, from an average of 6.3°C in January to 23.8°C in July. January is the coldest month with an average high temperature of 9.7°C and an average low temperature of 2.9°C. August is the warmest month with an average high temperature of 29.2°C and an average low temperature of 18.4°C During autumn and winter, from November to March, the temperature drops but is not lower than 6.7°C. The city receives approximately 2,500 hours of sun, making it one of the sunniest cities on the European Continent. Figure 18.1 illustrates the annual temperatures and average solar irradiance on the horizontal plane of Tirana.

18.3.3 Site selection

The main focus of the chapter is on three distinct types of housing in Tirana, which have been chosen based on their prevalence at the city-wide level and their susceptibility to low construction standards. This selection approach aims to increase the significance and relevance of the study's outcomes, as they may impact a larger number of households. The housing typologies that have been identified for the city of Tirana are Silicate Brick Buildings [SBT], Precast Concrete Buildings [PRT], and Informal House Units [INT].

18.3.3.1 Prefabricated Building (referred to as PRT)

The multi-family building was constructed as part of modular projects and prefabrication of panels between 1960 and 1980 to reduce costs and time for the production and assembly of

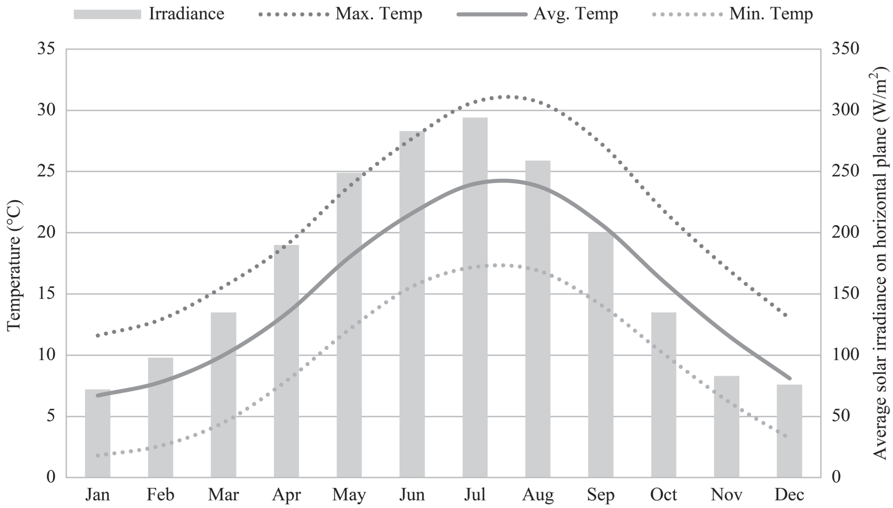

Figure 18.1 Annual temperatures and average solar irradiance on a horizontal plane for the city of Tirana.
Source: Extracted from Meteonorm.

housing units across the country (see Figure 18.2). The building's design consists of a vertical circulation node where the block of stairs is positioned in the centre. The rectangular floor plan has two sides left empty to allow it to be attached to other sections. The building has six apartments on each level, a mixture of one-bedroom and two-bedroom apartments. All apartments have two-way orientations and indirect ventilation. The panels used in the building were reinforced and poured into metal moulds before being treated with relevant technology. The external panels are 22 cm thick reinforced concrete, which also acts as a structural component and provides thermal insulation through the foam concrete layers. The layer of foam concrete is 14 cm thick while the partition panels dividing the functional areas are 14 cm thick reinforced vertical concrete. The building's roof and internal floors are horizontally reinforced concrete slabs.

18.3.3.2 Silicate Brick Building (referred to as SB)

This building, erected in 1970, is a multi-family structure containing 15 apartments located across five levels above ground. Access to each level is provided by staircases that lead to three apartments on each floor, consisting of two 2+1 apartments and one 3+1 apartment (as illustrated in Figure 18.3). Some of the apartments on the ground floor are currently serving commercial and service functions. The building's construction system features retaining walls made of red bricks, while the external walls, left unembellished on the outside, are plastered on the inside and 24 cm thick. Partition walls, which are 14 cm thick, are constructed using red bricks and serve as retaining walls. The flat, reinforced concrete slabs form the roof and internal floors.

18.3.3.3 Informal Building (referred to as IN)

The informal housing typology is prevalent in the informal areas of Tirana. This residential building has two levels and a square plan, featuring four rooms and two toilets (refer to Figure 18.4). The building's organization comprises a vertical circulation hub, with the staircase block inside the structure. The building's supporting columns are constructed of reinforced concrete, while the building envelope is made of aerated bricks plastered

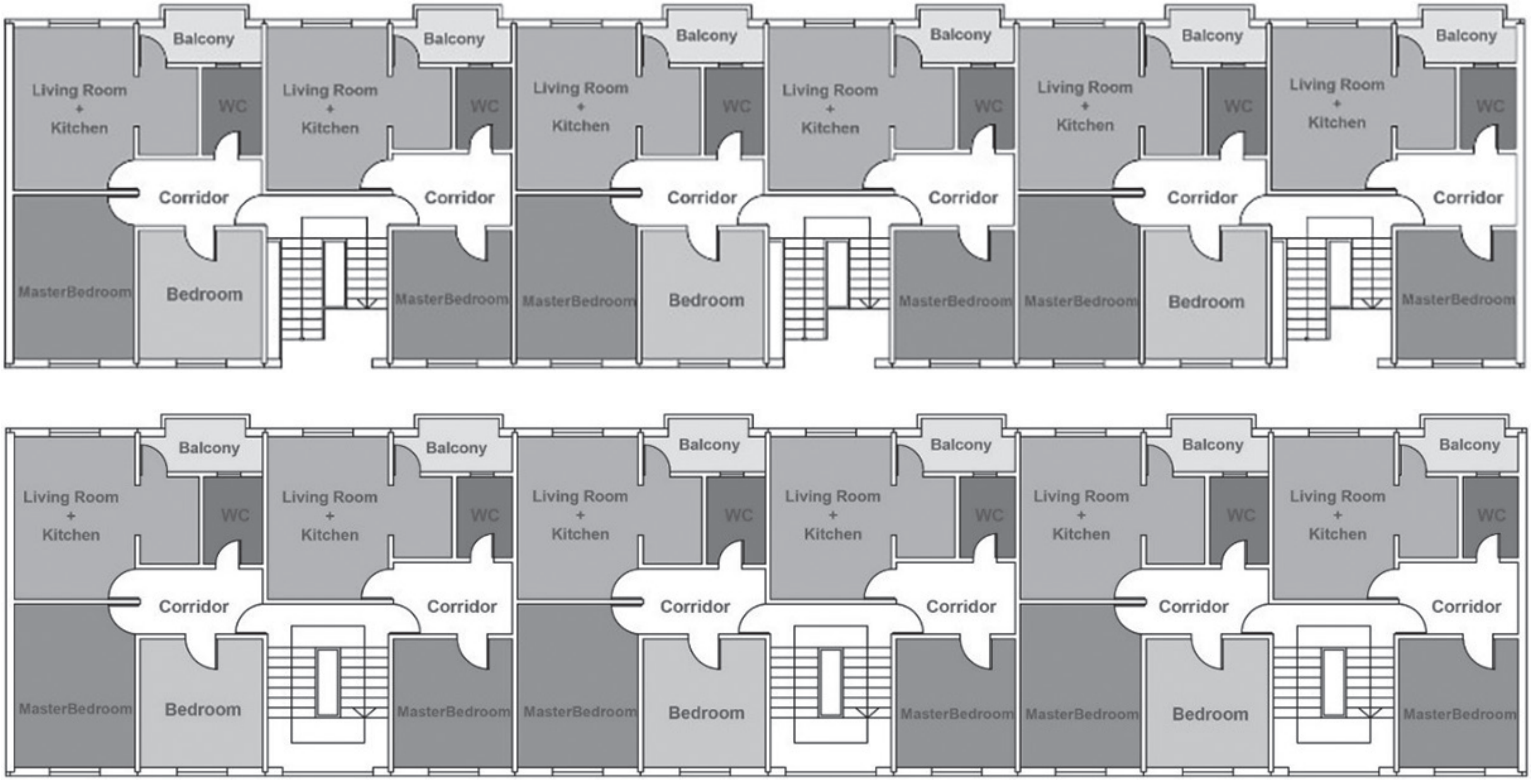

Figure 18.2 Building layout plans with associated functional spaces for [PRT] and [PRP] (ground and typical floor).

Source: Image courtesy of the authors.

Figure 18.3 Building layout plans with associated functional spaces for [SBT] and [RBP] (ground and typical floor).

Source: Image courtesy of the authors.

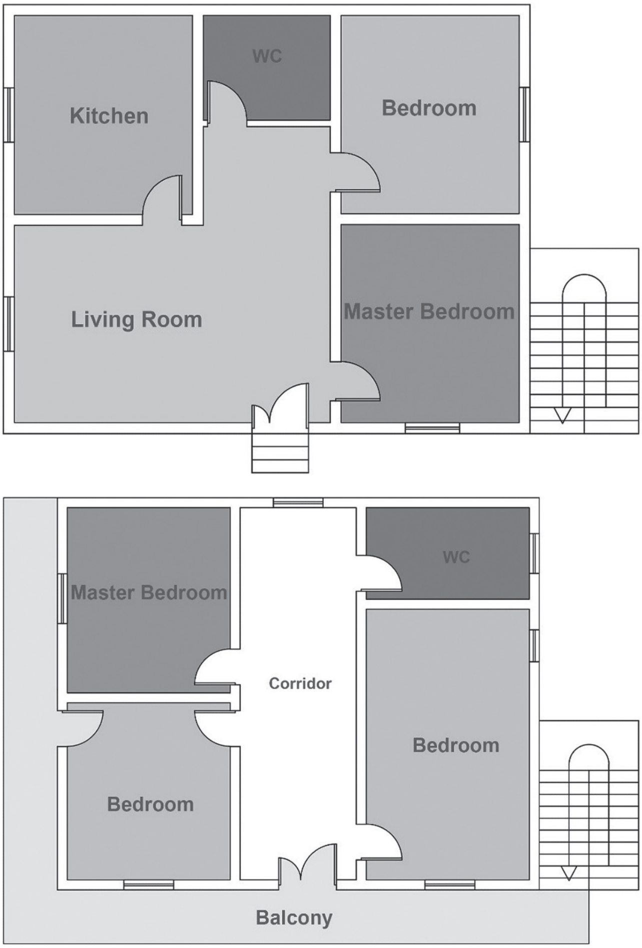

Figure 18.4 Building layout plans with associated functional spaces for [INT] (ground and first floor).

Source: Image courtesy of the authors.

on both sides, measuring 25 cm. The internal partitions also feature aerated bricks plastered on both sides, measuring 15 cm. The roof and interior floors of the building are constructed of horizontally reinforced concrete slabs. For more detailed technical information regarding the chosen typologies for Tirana, Albania, please refer to Table 18.1. As the table shows, electricity is the primary heating mode for the selected housing typologies while the households are highly sensitive to price changes in the electricity markets. Any increase in

Table 18.1 Technical information of the selected typologies for Tirana, Albania

Building code	*Floor Nr*	*Building area (m²)*	*WWR (%)*	*Apartment Nr*	*Density (people/m)*	*Heating system*	*Cooling system*
PRT	5	2,190	20.18	30	0.05	Electricity	–
SBT	5	1,313	18.7	15	0.05	Electricity	–
INT	2	149	5.51	–	0.03	Electricity	–

electricity prices could lead to a substantial increase in the household's energy bills, which could be a significant financial burden for households with low incomes. This sensitivity to market prices also implies that any increase in demand for electricity during peak periods may lead to a strain on the power grid, potentially leading to blackouts or other disruptions in the power supply. As such, finding ways to reduce electricity demand in the housing typologies through energy efficiency measures and building retrofits is crucial for improving the households' financial resilience and reducing the impact on the power grid.

18.3.4 Questionnaire

The questionnaire was designed to gather important information regarding the factors that affect energy consumption in each building. It enabled the researchers to analyse the social, economic, and cultural aspects that influence the inhabitants' relationship with the building. The survey targeted randomly apartment or house owners and inhabitants of the three selected building typologies in Tirana. The questionnaire comprised 26 questions and was divided into four sections: personal information section, energy poverty section, building information section, and energy consumption section. The personal information section collected data on the respondents' age, gender, education level, and occupation. The energy poverty section assessed the respondents' ability to pay for energy bills and their perception of energy poverty. The building information section gathered data on construction time, typology, geometry, and window-to-wall ratio (WWR). Finally, the energy consumption section aimed to collect data on the respondents' energy consumption patterns and behaviours. The questionnaire was developed and implemented over a two-month period from December 22, 2019, to February 20, 2020. During this period, 66 valid questionnaires were obtained from the targeted survey respondents.

18.3.5 Computational simulation

The DesignBuilder interface version 6 (2020) for EnergyPlus (2020) is chosen to develop the simulation. The selection is based on the validated accuracy of the DesignBuilder software procedure developed by the International Energy Agency. The local weather file for the various climatic contexts in Southeast Europe is generated through Meteonorm 7.3 (2016) software. To enhance the reliability and impact value of this parametric exploration, each model generated in the simulation tool is first calibrated. Data from site surveying, documentation, questionnaires, and electricity and biomass bills are used as input. Thus, the input parameters of occupancy schedules, local climate, heating and cooling schedules, manufacturing operation times, and building systems availability are set based on the actual case scenarios of the inhabitants of each building.

The data presented in Table 18.2 provide an overview of the actual construction details. A calibration process was carried out to match the energy consumption values obtained from the actual energy bills with the computational simulation output to ensure accuracy. The simulations were conducted over a one-year period, and the monthly energy demand was measured from the energy bills and converted to kWh m^{-2} to enable comparison. The results showed that the energy demand for each building was 9.5 Lek per kWh. This data was used to establish base-case scenarios and retrofit scenarios. The calibration process was deemed successful when the energy consumption values from the energy bills were close to the output values from the computational simulations. The energy demand for each building was measured and calibrated over one year and converted to kWh m^{-2} for comparison purposes. For biomass, the conversion equivalency was 1 kWh, equal to 4,500 L or 0.4 kg/h of wood.

Table 18.2 Description of the typologies (BR, PR, IN, respectively) and associated U-value assumptions regarding the relevant building components

Code	*U-Value* ($W\ m^{-2}\ K^{-1}$)	*Description*
BR	$U_{outer\ wall} = 2.804$	Outer Wall (0.27 m): Calcium Silicate Brick (0.25 m), cement sand render (0.02 m), no insulation.
	$U_{inner\ wall} = 2.632$	Inner Walls (0.16 m): Cement sand render (0.02 m), Calcium Silicate Brick (0.12 m), Cement sand render (0.02 m).
	$U_{roof} = 4.440$	Roof (0.17 m): Reinforced concrete (0.15 m), Cement sand render (0.02 m), no insulation.
	$U_{window} = 5.894$	Single Glazing, Clear, 3 mm
PR	$U_{outer\ wall} = 1.161$	Outer Wall (0.24 m): Reinforced concrete (0.04 m), Cast concrete lightweight dry (0.14 m), Reinforced concrete (0.04 m), plastered (0.02 m), no insulation.
	$U_{inner\ wall} = 3.839$	Inner Walls (0.14 m): Plaster (0.02 m), Reinforced concrete (0.04 m), Plaster (0.02 m).
	$U_{roof} = 4.440$	Roof (0.17 m): Reinforced concrete (0.15 m), Cement sand render (0.02 m), no insulation.
	$U_{window} = 5.894$	Single Glazing, Clear, 3 mm
IN	$U_{outer\ wall} = 0.958$	Outer Wall (0.27 m): Cement sand render (0.02 m), Brick-aerated (0.25 m), Cement sand render (0.02 m), no insulation.
	$U_{inner\ wall} = 1.250$	Inner Walls (0.16 m): Cement sand render (0.02 m), Brick-aerated (0.12 m), Cement sand render (0.02 m).
	$U_{roof} = 4.440$	Roof (0.17 m): Reinforced concrete (0.15 m), Cement sand render (0.02 m), no insulation.
	$U_{window} = 5.894$	Single Glazing, Clear, 3 mm

18.3.6 Scenarios

The first retrofit scenario, [SC01], involves making improvements to the thermal insulation of the walls. The second scenario, [SC02], involves making improvements to the roof insulation, while the third scenario, [SC03], focuses on improving the glazing. Scenario [SC04] is a combination of the best options from scenarios [SC01] and [SC03], while scenario [SC05] combines [SC02] with [SC03]. The sixth scenario, [SC06], involves applying the best thermal insulation for the walls, roof, and windows. The seventh scenario, [SC07], aims to increase natural ventilation from 5 to 10 ac/h, while scenario [SC08] involves increasing the WWR by 15%. In Table 18.3, Tirana's scenarios [SC01-SC08] are illustrated, along with the U-value assumptions for the relevant building components for each typology. These scenarios are important in evaluating the impact of different passive interventions on energy consumption reduction and thermal performance. By simulating each scenario using the DesignBuilder interface, the energy consumption and thermal performance results can be compared to the base case scenario, [BC], to assess the effectiveness of each intervention. This information can be useful in identifying the most effective interventions for reducing energy consumption and improving thermal performance in Tirana's building stock.

18.4 Results and discussion

18.4.1 Questionnaire results

A survey was administered to 66 homeowners residing in the selected building types in Tirana. Most of the homeowners fell into the age group of 45–65, with the remainder belonging to the age group of 36–45. When asked about their monthly income, it was discovered that 50% of

Table 18.3 Retrofitting scenarios of the typologies (BR, PR, IN, respectively) and associated U-value assumptions regarding the relevant building components

Code	*Scenario*	*U-Value ($W\ m^{-2}\ K^{-1}$)*	*Description*
SC 1	Wall Insulation	U_{Walls} = 0.469 (SBT) U_{Walls} = 0.591 (PRT) U_{Walls} = 0.436 (INT)	EPS Expanded Polystyrene (5 cm)
SC 2	Roof Insulation	U_{Roof} = 0.301	XPS Extruded Polystyrene (10 cm) + 3 cm Screed + 1 cm Roofing Felt
SC 3	Window Glazing	$U_{glazing}$ = 2.665	Double, Clear Glazing 6 mm/13 mm Air
SC 4	Wall Insulation + Double Glazing		
SC 5	Roof Insulation + Double Glazing		
SC 6	Wall + Roof Insulation + Double Glazing		
SC 7	Natural Ventilation (ac/h) = 10		
SC 8	WWR increased by 15%		

the homeowners in the [PRT] type, 30% of those in [SBT], and 28% of those in [INT] had an income of less than 380 euros, which is considered low average income. According to data from the World Bank for 2021, the median income in Albania will be $5,188 per year, or $432 per month. The second most frequent response for income fell in the range of 120–300 euros, with 10% in [SBT], 50% in [PRT], and 20% in [INT]. The findings mentioned above are summarized in Figure 18.4.

Regarding the concept of energy poverty, it was found that only a fraction of householders in Tirana had knowledge of it. A crucial aspect of the survey was the building-related questions. In terms of house insulation, a significant proportion of residents in [SBT] (45%), [INT] (40%), and [PRT] (25%), reported having no insulation in their homes. For [SBT], 45% claimed to have only wall insulation, whereas [INT] (45%), [PRT] (25%), and [SBT] (11%) have both wall and roof insulation. In the energy consumption section of the survey (refer to Figure 18.4), it was found that all the apartments and houses in Tirana use electricity for heating. Residents of [PRT] and [SBT] reported the highest levels of temperature discomfort during the winter or summer, but even [INT] residents claimed to experience discomfort frequently. When it comes to difficulties with electricity bill payments, a significant proportion of respondents reported having problems. However, most of them managed the situation by cutting other expenses, avoiding late payments, and resolving issues with electricity bill payments.

The questionnaire results presented in Figure 18.5 provide valuable insights into the different aspects of the three building typologies in Tirana. The data collected from the householders reveals interesting trends and patterns in relation to monthly income, building insulation, window glazing, window frame, energy used for heating, thermal comfort, electricity spent for space heating/cooling, and electricity bill payment.

18.4.2 Energy consumption

Figure 18.6 presents a comparison of the annual energy use for heating, cooling, and total energy consumption among the actual real case (RC), base case (BC), and eight different scenarios (SC 01–SC 08) for three building typologies: Prefabricated Building [PRT], Silicate Brick

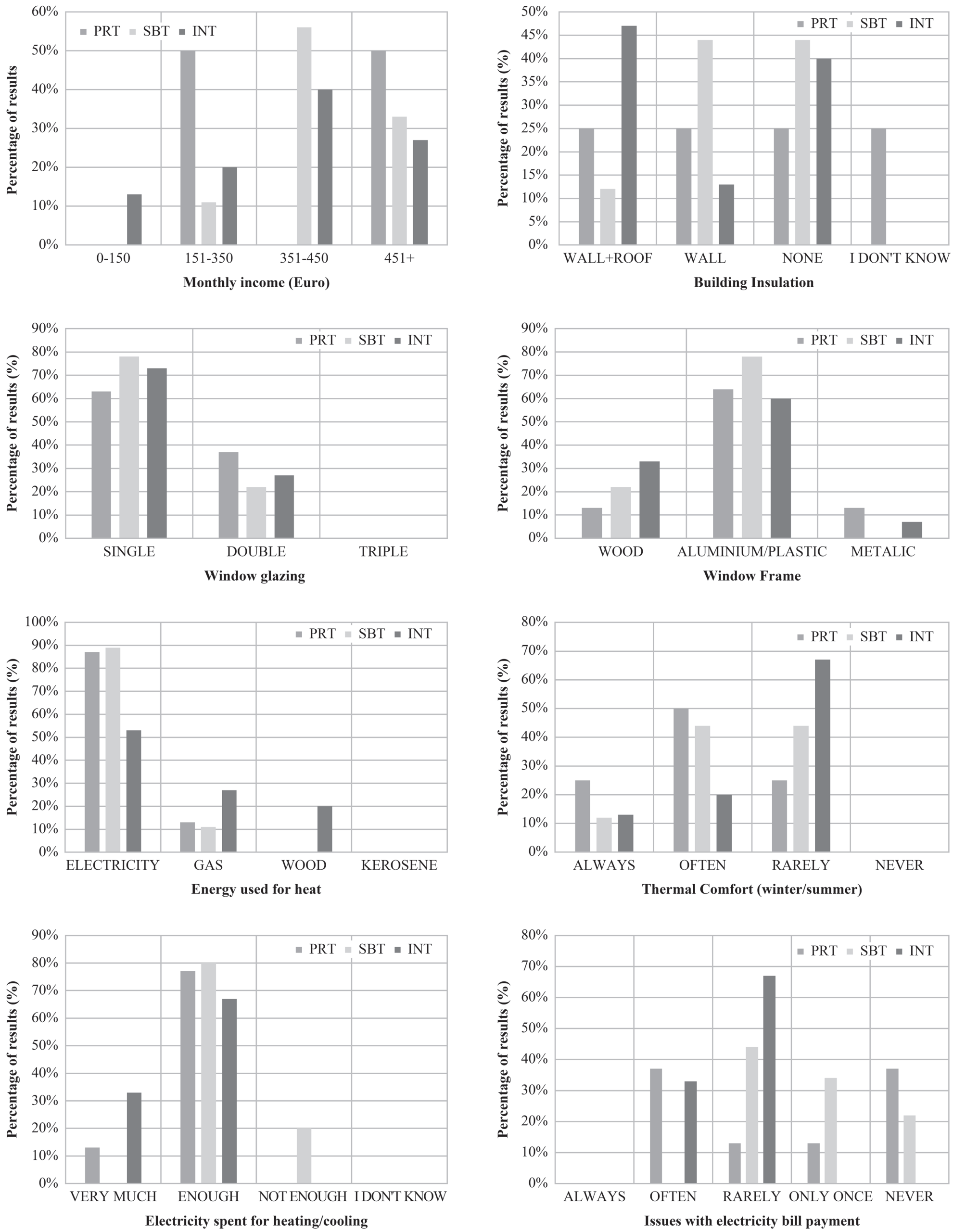

Figure 18.5 The results of questionnaires (%) of Prefabricated Building [PRT], Silicate Brick Building [SBT], and Informal Building [INT] typologies related to monthly income, building insulation, window glazing, window frame, energy used for heating, thermal comfort, electricity spent for space heating/cooling and electricity bill payment.

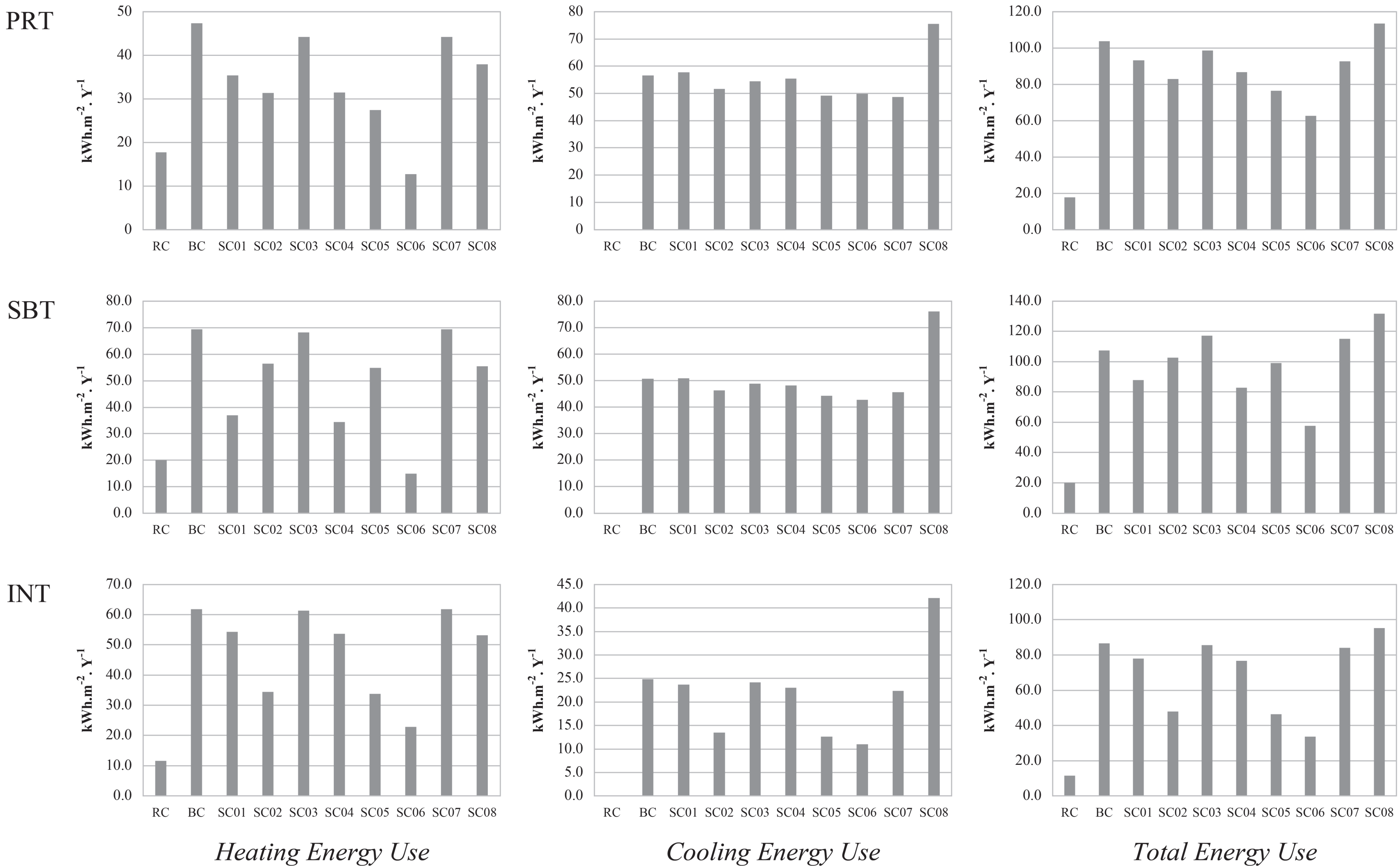

Figure 18.6 Computational evaluation of heating, cooling, and total energy use for Prefabricated Building [PRT], Silicate Brick Building [SBT], and Informal Building [INT] typology throughout one year in Tirana. Comparison of annual total energy demand for the real case (RC), base case (BC), and the eight scenarios (SC 01–SC 08).

Table 18.4 Energy reduction (%) of the refurbishment scenarios for total energy use

	PR	*BC*	*SC 1*	*SC 2*	*SC 3*	*SC 4*	*SC 5*	*SC 6*	*SC 7*	*SC 8*
PRT	kWh m^{-2}	103.9	93.2	82.9	98.6	86.8	76.5	62.6	92.5	113.5
	% Reduction	–	**10.3%**	**20.2%**	**5.1%**	**16.5%**	**26.4%**	**39.7%**	**11.0%**	**−9.2%**
SBT	kWh m^{-2}	107.4	87.8	102.5	117.1	82.7	99.0	57.7	115.0	131.5
	% Reduction	–	**18.2%**	**4.6%**	**−9.0%**	**23.0%**	**7.8%**	**46.3%**	**−7.1%**	**−22.4%**
INT	kWh m^{-2}	96.6	78.0	47.9	85.5	76.8	46.4	33.8	84.1	95.4
	% Reduction		**19.3%**	**50.4%**	**11.5%**	**20.5%**	**52.0%**	**65.0%**	**12.9%**	**1.2%**

Building [SBT], and Informal Building [INT]. In Table 18.4, the percentage of energy reduction resulting from each scenario's implementation compared to the base case scenario is displayed. The graphs in Figure 18.5 reveal that the actual energy consumption scenario falls short of the required energy consumption based on each building's conditions, as indicated by the base case scenario [BC]. This indicates that the occupants of the considered buildings live in energy poverty when they resort to underconsumption strategies. The simulation results indicate that modifications to the building fabric can improve each building typology's energy performance. Specific combinations of improvement scenarios display high thermal performance, with the most effective being the first three scenarios (SC 6), followed by wall and glazing replacement (SC 5), and finally, wall and ceiling insulation (SC 2).

For Prefabricated Building [PRT], the results on energy consumption fluctuate between 103.9 kWh m^{-2} Y^{-1} (base case) and 62.6 kWh m^{-2} Y^{-1} (SC 6). Specifically, SC 6 reduces the annual total energy demand by up to 39.7%. The energy consumption of Silicate Brick Building [SBT] fluctuates between 107.4 kWh m^{-2} Y^{-1} (base case) to 57.7 kWh m^{-2} Y^{-1} (SC 6). Scenario six (SC6) reduces the annual total energy demand to 46.3%. Energy consumption in Informal Building typology [INT] fluctuates between 96.6 kWh m^{-2} Y^{-1} (base case) and 33.8 kWh m^{-2} Y^{-1} (SC 6). Scenario six (SC6) reduces the annual total energy demand to 65.0%.

The energy consumption for Prefabricated Buildings [PRT] varies from 103.9 kWh m^{-2} Y^{-1} (base case) to 62.6 kWh m^{-2} Y^{-1} (SC 6), reducing up to 39.7% in the annual total energy demand. Silicate Brick Building [SBT] also shows fluctuations in energy consumption, ranging from 107.4 kWh m^{-2} Y^{-1} (base case) to 57.7 kWh m^{-2} Y^{-1} (SC 6) reduces the annual total energy demand by 46.3%. Informal Building [INT] shows the most significant reduction in energy consumption, with variations ranging from 96.6 kWh m^{-2} Y^{-1} (base case) to 33.8 kWh m^{-2} Y^{-1} (SC 6), reducing the annual total energy demand by 65.0%. The sixth scenario (SC6) is the most effective in reducing energy consumption for all building typologies.

Energy-poor buildings are one of the most important topics, where the objective of decreasing the final energy demand and achieving energy efficiency must be attained. Nevertheless, choosing a type of support that will be feasible regarding the household's income is necessary. At the same time, the support must be practical for the shortest payback period possible and a decrease in energy demand. A programme focusing on energy poverty decrease should be based on the requirements of the affected households. It should provide sufficient support, aiming primarily at decreasing household energy expenditures while achieving higher comfort.

18.5 Conclusions

The study's main objective is to evaluate energy poverty in Tirana, Albania, and develop potential energy retrofit scenarios to improve energy performance. The residential stock in Tirana is made up of poorly constructed buildings with no insulation or thermal comfort, leading to low-quality buildings and energy poverty. The study's selection criteria for the building typologies aim to represent Tirana's different types of buildings. The authors aim to contribute to developing policies and strategies to address energy poverty in Tirana and improve living conditions for residents. The study's findings can provide policymakers and other stakeholders with insights into practical ways to tackle energy poverty in similar settings.

Eight easily implemented scenarios are explored, focusing on the building envelope retrofit. The retrofit packages result in more success than others in dependence on the improved elements and their impact on a particular floor or building. Given Tirana's climatic conditions, houses require heating and cooling during the year. The best scenario for Tirana (lowering energy consumption and achieving thermal comfort) is SC06. It combines the wall (5 cm) with roof insulation and double glazing. The SC06 scenario has a more significant impact in the [SBT] typology (46.3% energy demand reduction), followed by the [PRT] typology (39.7% energy demand reduction) and [INT] typology (65.0% energy demand reduction). The typology that requires higher energy consumption to achieve thermal comfort is the [SBT] typology, followed by the [PRT] typology and [INT] typology.

The study evaluates eight scenarios focusing on building envelope retrofit, which is relatively easy to implement. The success of each retrofit package depends on the elements being improved and their impact on specific floors or buildings. Tirana's climate requires heating and cooling throughout the year, making energy consumption a critical issue. Among the eight scenarios, SC06 is the most effective in achieving thermal comfort and reducing energy consumption. It involves wall insulation (5 cm), roof insulation, and double glazing. The impact of SC06 is most significant in the SBT typology, reducing energy demand by 46.3%, followed by the PRT typology (39.7% energy demand reduction) and INT typology (65.0% energy demand reduction). Among the three typologies, the SBT requires the highest energy consumption to achieve thermal comfort, followed by PRT and INT. Overall, the study highlights the importance of building envelope retrofit to reduce energy consumption and address energy poverty in Tirana.

The impact of various factors such as climatic conditions, building fabric, orientation, window-to-wall ratio (WWR), and construction technique on energy use has been identified through simulation results. Each of these factors plays a crucial role in determining the overall energy performance of a building. For instance, the climatic conditions in a particular region can significantly influence the heating and cooling required to maintain thermal comfort indoors. Similarly, the building fabric, such as insulation in walls and ceilings, can help reduce the energy demand for heating and cooling.

Moreover, the orientation of a building and the WWR can impact the amount of solar radiation entering the building and, consequently, affect the heating and cooling needs. Finally, the construction technique used in building design can also impact energy demand, with more energy-efficient designs typically resulting in lower energy use. The simulation results highlight the need to consider these factors when designing and retrofitting buildings to improve their energy performance and achieve thermal comfort for occupants.

To overcome the challenges associated with residential retrofit practices in Albania, a comprehensive approach involving multiple stakeholders is required. The government must lead in developing policies and initiatives that encourage building owners and residents to invest in energy-efficient retrofitting measures. In addition, building owners and residents must be educated about the benefits of energy-efficient retrofitting and the various options available. This can be done through public awareness campaigns, training programmes, and workshops that provide information on retrofitting techniques, products, and services. Addressing energy poverty and promoting energy-efficient retrofitting in Albania requires a multi-faceted approach involving the government, building owners, residents, and other stakeholders. With the right policies, incentives, and education, it is possible to transform Albania's building stock and improve the quality of life for its citizens.

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