Deep REnovation roadmaps to decrease households VulnERability to Energy poveRty

Project No. 101076277

Annex to Deliverable 3.4 - Renovation roadmaps

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Annex I: Roadmap I - Single-Family Buildings in Brezovo

Co-funded by the European Union

REVERTER

Executive summary

The REVERTER roadmaps aim to combat energy poverty through the deep renovation of dwellings occupied by vulnerable households. The roadmaps were developed considering the conclusions and policy recommendations that resulted from the analysis of the best practices and the different characteristics and conditions of the targeted countries. To this end, the roadmaps are tailor-made to the characteristics of the building stock, the characteristics of the vulnerable households, the legislative framework, and the climate conditions of each pilot, while they intend to cover a sufficiently cohesive group of cases that will allow for a larger-scale rollout and replication of the proposed actions for the effective analysis and tackling of the problem. Moreover, the roadmaps target the worst-performing homes first (worst first principle) and promote the most cost-effective energy efficiency and RES interventions (best-possible principle) to ensure that the economic, energy, climate, and social benefits triggered by the implementation of the required energy efficiency and RES interventions are maximised.

The aim of Roadmap I “Single-family Buildings in Brezovo” is to help alleviate energy poverty in single-family buildings in the Municipality of Brezovo through the energy renovation of the building stock. There are approximately 2,700 single-family houses in the area of interest and around 20% are occupied by energy-poor households. Hence, the present Roadmap aims to renovate around 20% of the occupied residential buildings by 2050, considering the average percentage of energy poverty in Brezovo. Based on the home visits conducted so far and expert assessment, insulation of the building envelope, replacement of old inefficient heating/cooling systems and RES interventions (installation of solar thermal systems and roof PV installations) are recommended.

Focusing specifically on renovations triggered by the project (i.e. till the end of the project and 5 years beyond project-end), the impacts are summarised in Table ES1. It is noted that the planned investments will be carried out with 100% public funding.

Table ES1. Contribution of the REVERTER project to the implementation of the specific roadmap for the renovation of single-family buildings in the period 2025-2030.

Impacts	Energy-poor households – Single-family buildings
Number of renovated buildings	48
Resulted cumulative final energy savings (GWh)	0.35
Resulted cumulative primary energy savings (GWh)	0.64
Resulted cumulative CO_2 reduction (ktn CO_2)	0.12
Resulted employment impacts (person-years)	30.3
Resulted cumulative multiple benefits (million €)	0.007
Required new investments (million €)	1.95

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1 Introduction

1.1 Analysis of the main objectives of the renovation roadmap

The building renovation roadmap aims to ensure the alleviation of energy poverty in the Brezovo pilot. In particular, Roadmap I aims to establish a clear framework, address the energy poverty for households living in single-family houses, tailor specific strategies to local conditions, assess the existing building stock, and guide the successful implementation of energy-efficient renovations.

A detailed social survey was conducted to understand the current levels of energy poverty, providing a baseline that highlights the challenges faced by residents. Also, a PESTEL analysis identified the challenges and opportunities related to different aspects of the renovation process.

The single-family building renovation roadmap wishes to accelerate the renovation of the building stock until 2050 setting the ambitious goal for renovation of 98% of the occupied buildings.

1.2 Main energy, environmental and climate change legislative and policy framework at national level

Policies for sustainable energy development in Bulgaria are defined in the following main energy laws - **Law on Energy Efficiency** and **Law on Energy from Renewable Sources**, which both require the development of several national documents that must be complied with by all regional governments, namely:

Integrated plan for energy and climate of the Republic of Bulgaria 2021 – 2030 (NECP) - defines the country's main goals for stimulating low-carbon economic development, developing competitive and secure energy and reducing dependence on fuel and energy imports. To achieve the goals set in the plan, complex actions are needed in all spheres of socio-economic relations. This is especially true for economic sectors where the potential of existing industries to adopt new technologies must be fully exploited, ensuring a smooth and fair transition to a climate-neutral circular economy, such as the hydrogen economy.

The national energy priorities set out in the plan are summarized as follows:

- increasing energy security and diversification of energy resource supplies;
- development of an integrated and competitive energy market;
- use and development of renewable energy, according to the available resource, network capacity and national specificity;
- increasing energy efficiency by developing and applying new technologies to achieve modern and sustainable energy;
- consumer protection by guaranteeing fair, transparent and non-discriminatory conditions for using energy services.

Based on the Bulgarian Integrated Energy and Climate Plan in 2030, Bulgaria plans to achieve a 27.89% reduction in primary energy consumption and a 31.67% reduction in final energy consumption. It also intends to reach a 27.09% share of RES in gross final energy consumption by 2030, a 30.33% share of renewable electricity and a 42.60% share of renewable energy for heating and cooling.

National Recovery and Resilience Plan - The main objective of the Recovery and Resilience Plan is to facilitate economic and social recovery from the crisis caused by the COVID-19 pandemic. The green transition occupies a leading position in the Recovery and Sustainability Plan of Bulgaria, concentrating 45.8% of the total estimated costs, with a minimum set of 37% of the European Commission regulation. In this way, Bulgaria contributes to the fulfillment of the pan-European goals for gradual decarbonization. In addition, efforts are focused on three main areas:

- Creation of conditions for accelerated introduction of renewable energy sources and hydrogen;
- Enhanced actions to increase the energy efficiency of the economy;
- Sustainable mobility.

Strategy for sustainable energy development of the Republic of Bulgaria until 2030 with a horizon until 2050 - reflects the trends, measures and policies in the field of energy security, energy efficiency, the liberalization of the electricity and gas markets and their integration into the common European energy market, the development and implementation of new energy technologies. These policies are also reflected in the Integrated Energy and Climate Plan.

The strategy defines the following main priorities:

- Guaranteeing energy security and sustainable energy development;
- Development of an integrated and competitive energy market and consumer protection by guaranteeing transparent, competitive and non-discriminatory conditions for the use of energy services;
- Increasing energy efficiency in the processes from production to final energy consumption;
- Sustainable energy development for clean energy and decarbonization of the economy;
- Implementation of innovative technologies for sustainable energy development.

National Plan for Near Zero Energy Buildings - Local authorities are required to implement the plan under the National Plan for Near Zero Energy Buildings 2015-2020 which aims to make the concept of near zero energy buildings of energy a practically viable alternative to future construction of new buildings in Bulgaria, as well as to implement a proven approach for profitability.

Law on energy efficiency - This law regulates public relations related to the implementation of the state policy to reduce energy efficiency. The law aims to increase energy efficiency as part of the country's sustainable development policy through:

1. use of a system of activities and measures to reduce energy efficiency in production, transmission and distribution, as well as in the final consumption of

energy;

2. introduction of obligation schemes for energy needs;

3. development of the market of energy-efficient services and especially the provision of energy-efficient services.

1.3 Identification of the key stakeholders including the procedures for their engagement

The state policy on energy efficiency is implemented by:

- the Minister of Energy - in the field of energy efficiency in the production, transmission and distribution of energy, as well as in the final consumption of energy;
- the Minister of Economy - in the field of increasing energy efficiency in small and medium-sized enterprises, as well as in the energy consumption of industrial systems;
- the Minister of Regional Development and Public Works - in the field of development, harmonization and introduction of technical rules and norms in the field of energy characteristics of buildings, the implementation of projects and programs related to renovation of the housing stock and improvement of energy efficiency in residential buildings in the Republic of Bulgaria;
- the Minister of Transport, Information Technologies and Communications - in the field of energy efficiency in the transport sector.

The activities of implementing the state policy for increasing energy efficiency are carried out by the executive director of the Agency for Sustainable Energy Development (SEDA). SEDA performs activities and services related to the implementation of the state policy to increase energy efficiency, as well as to promote the production and consumption of electrical energy, thermal energy and energy for cooling from renewable sources, the production and consumption of biogas and green hydrogen, as well as the production and consumption of energy from renewable sources in transport, renewable liquid and gaseous transport fuels of non-biological origin and recycled fuels in transport.

The implementation of the envisaged building renovation roadmap requires the involvement of various bodies and authorities, which are illustrated in Figure 1. The mapping of the involved bodies and authorities pinpoints that the development of a governance mechanism, which will facilitate the communication and cooperation of the entities involved, is imperative.

The identified bodies and authorities represent different administrative and social levels with completely different priorities and aspirations. The cooperation of these stakeholders is crucial in identifying the energy-poor households facilitating their participation in the planned policies and measures and collecting the necessary data to evaluate both the implemented policies and measures and the evolution of the energy poverty phenomenon at the national, regional and local level.

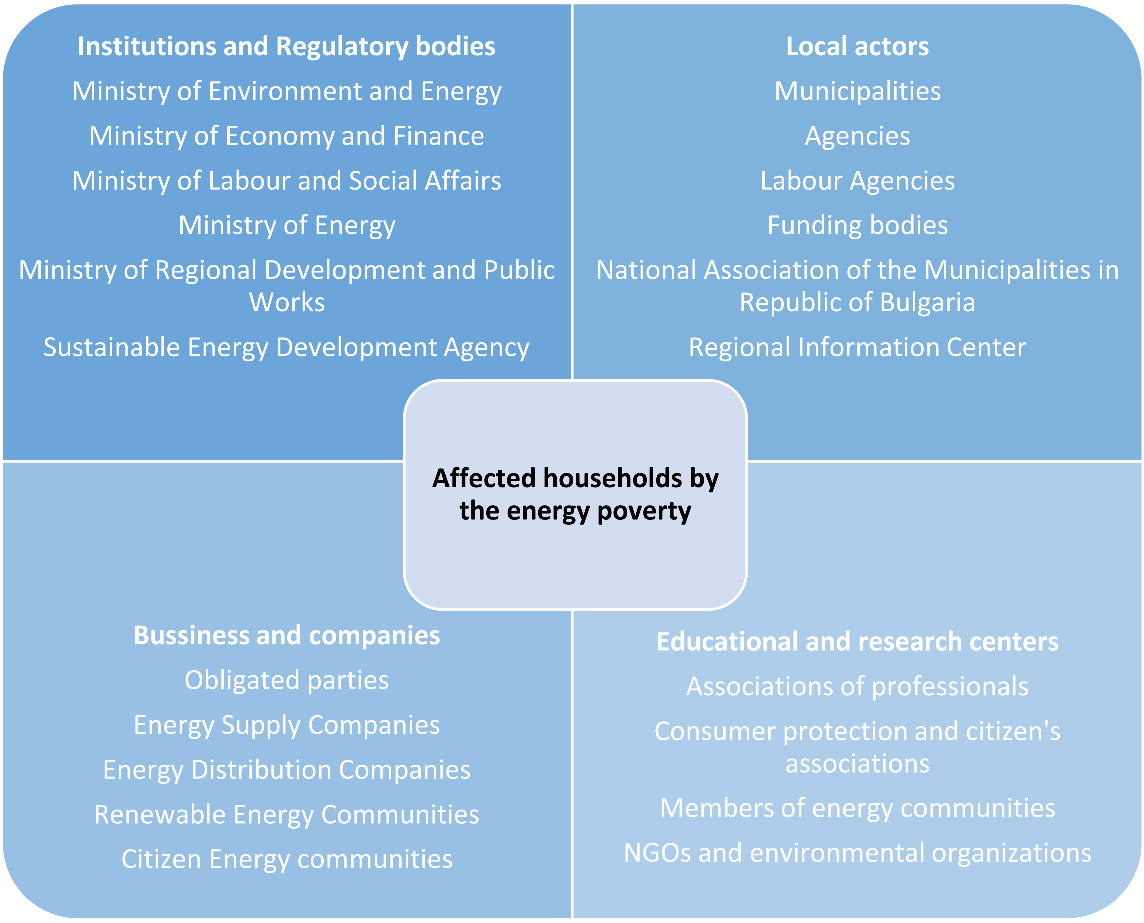

Figure 1. Overview of the involved stakeholders into the preparation of the building renovation roadmap.

Different means will be utilized to conduct the foreseen consultation activities, such as indicatively:

- Organization of a workshop with the participation of the identified stakeholders to discuss the main provisions of the building renovation roadmap.
- Launch an open consultation procedure with the Regional Information Center
- Organization of a workshop with the participation of the identified stakeholders to discuss the received comments during the consultation procedure.

2 Analysis of the current levels of energy poverty in the pilot area

The analysis of the current situation of energy poverty and vulnerability of the population in the area of the Brezovo pilot was based on data from Eurostat's EU SILC and HBS surveys. More specifically, the National Statistical Institute of the Republic of Bulgaria provided EU SILC survey microdata (at the household level) for the years 2017-2021 and HBS data for the years 2017-2019 and 2021. Nevertheless, the HBS data didn't include derived variables at the household level referring to household size and type, equivalent size, number of persons per age class, number of persons who are working or are unemployed, etc. From the dataset, the observations selected were those that referred to region BG42 (variable DB040) and degree of urbanisation 3 (variable DB100 - rural area/thinly populated area). This subset of the data includes other areas than Brezovo but with similar characteristics.

As shown in Figure 2, the share of the population living in a dwelling with leaks, damp or rot in the area of the Brezovo pilot is higher than the national share (almost by 1-2%). The same is true for the share of the population not able to keep their home adequately warm (Figure 3). However, the difference decreases over the years (i.e., from 8.9% in 2017 to 1.5% in 2021). In contrast, the share of the population having arrears on utility bills is lower in the pilot area compared to the national indicator (Figure 4). Again, the difference decreases over the years (i.e., from 10.3% in 2019 to 3.1% in 2021). In general, it appears that the consensual EP indicators in the pilot area are approaching the corresponding national indicators over time and, as is the case nationally, are improving.

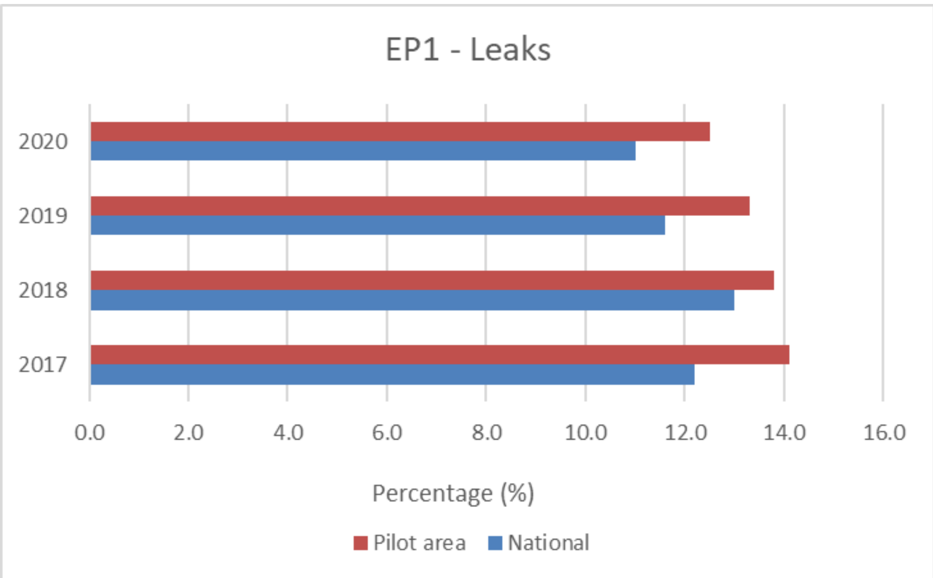

Figure 2. Share of total population living in a dwelling with leaks.

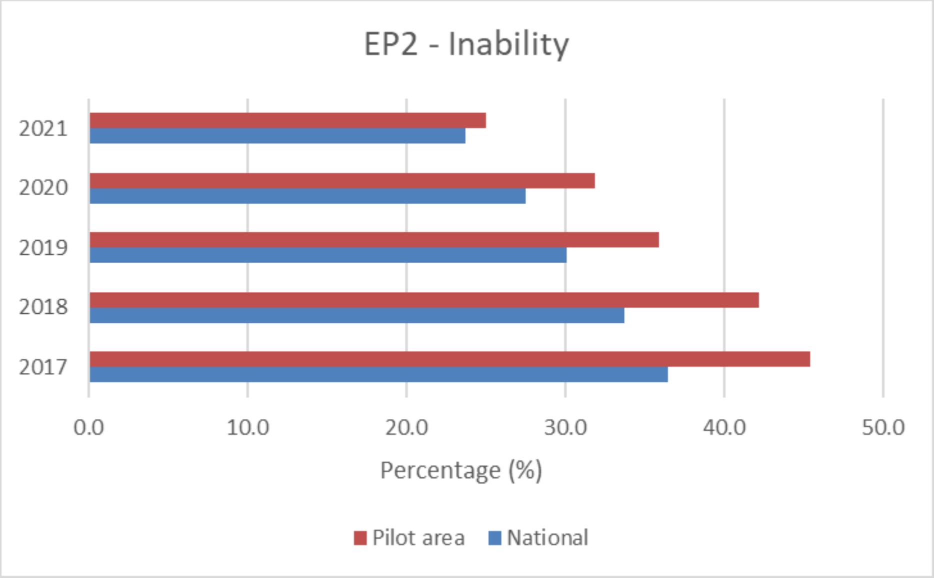

Figure 3. Share of population not able to keep home adequately warm.

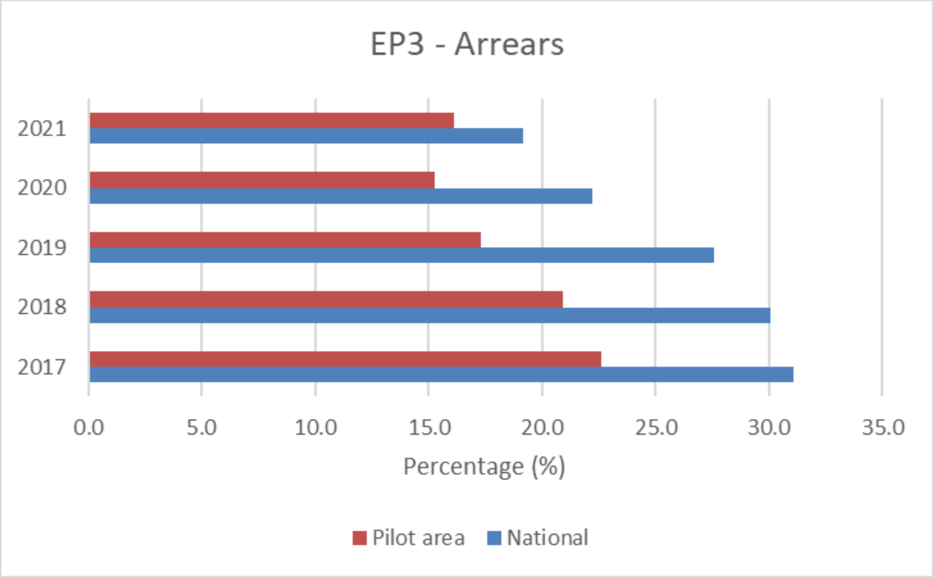

Figure 4. Share of population having arrears on utility bills.

The rest of the EP indicators (i.e., EP4 to EP12) were studied only at the pilot area level, as they are not official indicators. Looking at Figure 5 and Figure 6, it can be seen that the share of the population having arrears on utility bills only once is more or less stable (around 8%) but the corresponding share of those who have arrears on their bills twice or more has been significantly reduced (by more than 40% in the last five years).

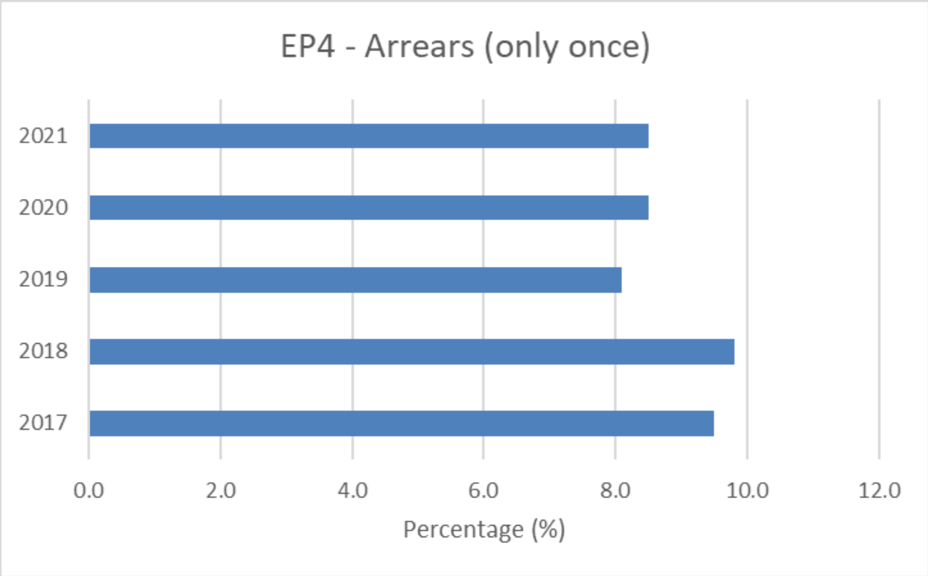

Figure 5. Share of population having arrears on utility bills only once in the past 12 months.

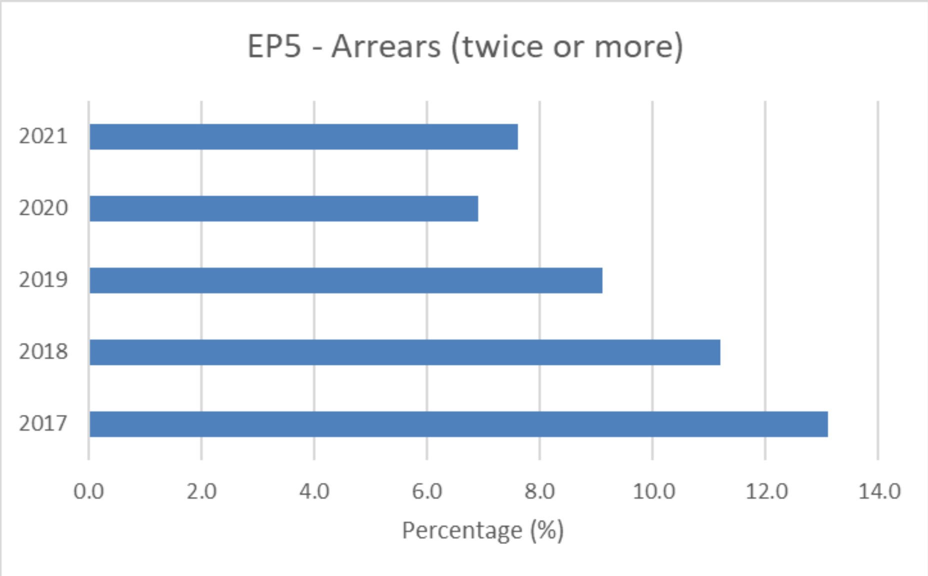

Figure 6. Share of population having arrears on utility bills twice or more in the past 12 months.

The reduction in the intensity of the problem is also reflected in the results of the Weighted Composite Indices (WCI). As shown in Figure 7, the percentage of the population not experiencing EP issues increased from 43% in 2017 to 55.3% in 2020. More importantly, the percentage of those experiencing severe EP issues (i.e., the WCI1 is equal to 1) has been reduced by around 50%, from about 4% to 2%. Similar conclusions are drawn from Figure 8 (WCI2) and Figure 9 (WCI3).

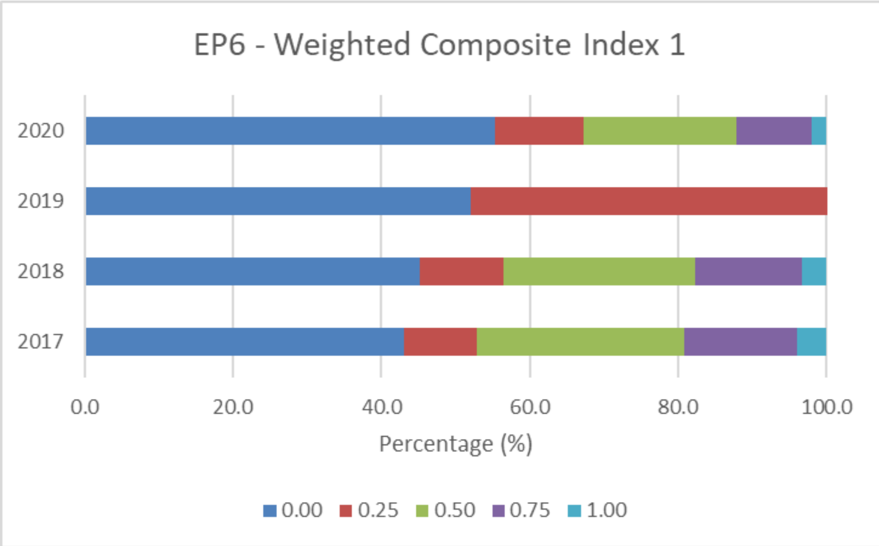

Figure 7. Share of population at EP according to WCI1.

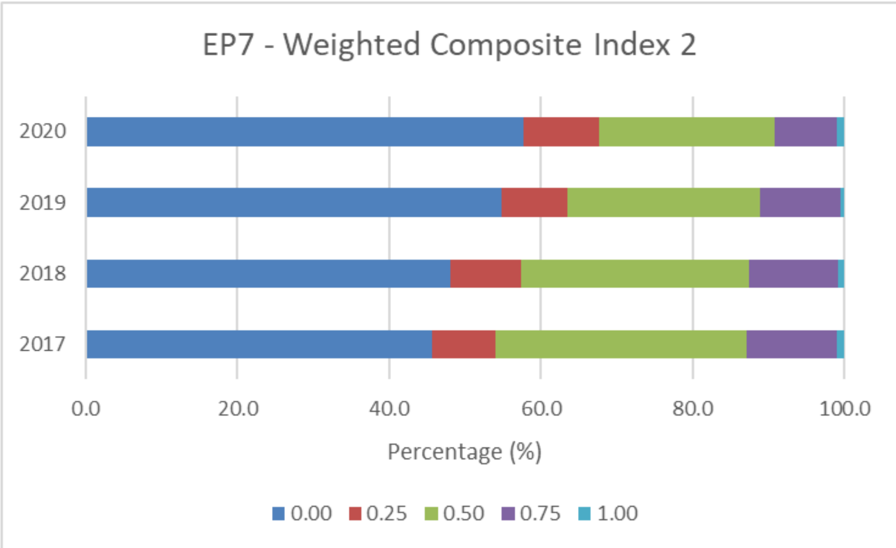

Figure 8. Share of population at EP according to WCI2.

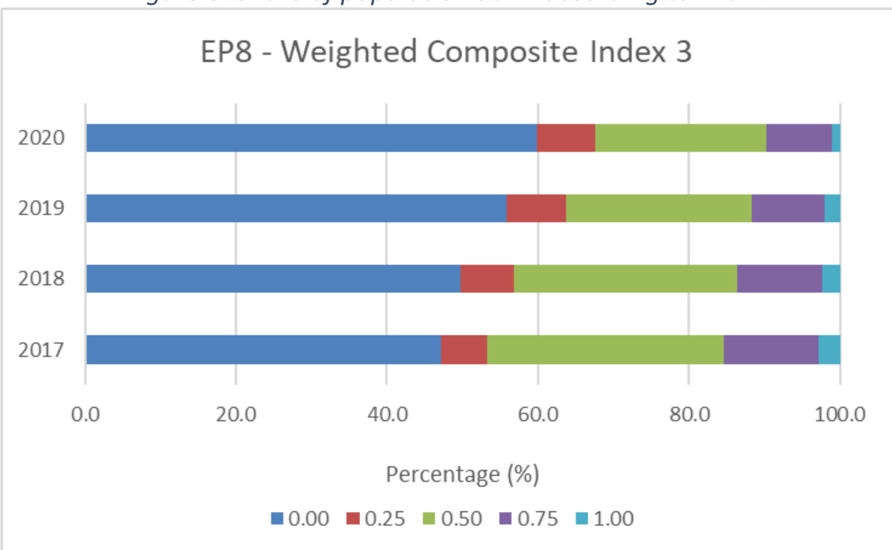

Figure 9. Share of population at EP according to WCI3.

The Simple Composite Indices (SCI) reveal a similar pattern of EP evolution. In all SCIs (Figure 10, Figure 11 and Figure 12), the share of the population not experiencing EP issues is increasing and the proportion experiencing the most important EP problems (classes 2 and 3) is decreasing. For instance, according to SCI3 (Figure 12) the EP rate for class 2 has been reduced from 13.9% to 9.1% (a percentage reduction of 34.4%) and for class 3 from 2.9% to only 1% (a percentage reduction of 63.9%).

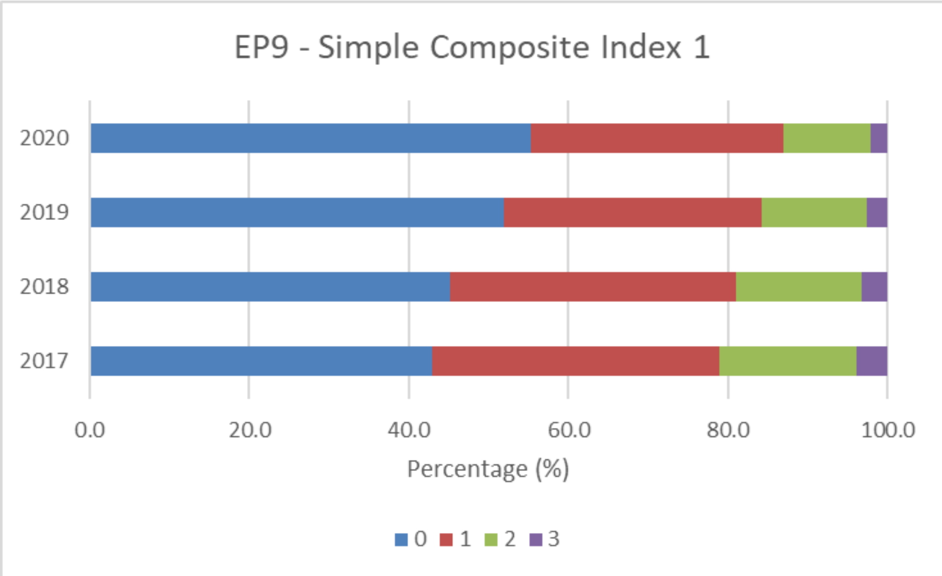

Figure 10. Share of population at EP according to SCI1.

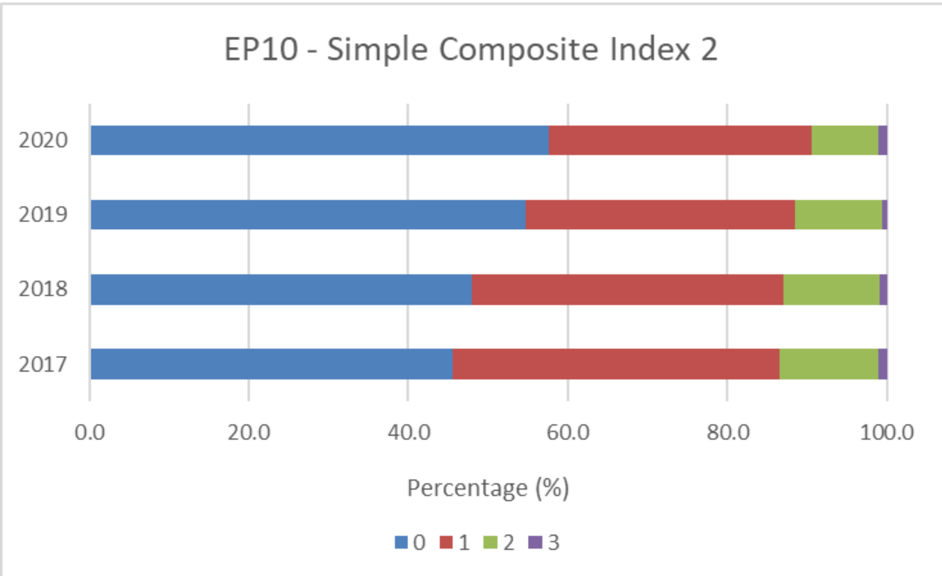

Figure 11. Share of population at EP according to SCI2.

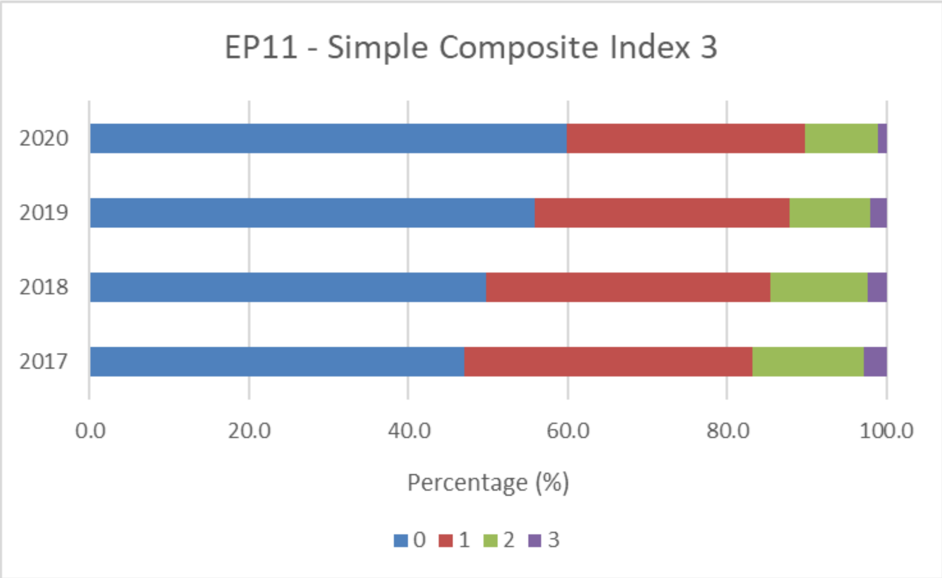

Figure 12. Share of population at EP according to SCI3.

Finally, the proportion of the population in the pilot area that experiences any type of EP, i.e., arrears on utility bills, leaks or inability to keep their house warm, presents also a decreasing trend (Figure 13). It may be redundant, but it should be noted that the percentage of EP households is significantly high based on this indicator, as practically all individual energy poverty indicators are added together.

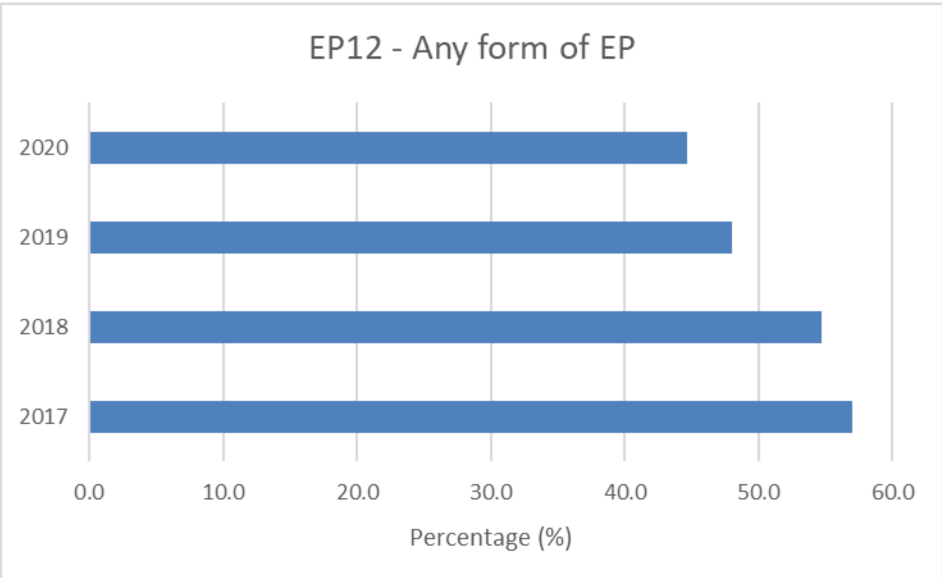

Figure 13. Share of population at EP according to EP12.

As mentioned, the Bulgarian HBS dataset didn't include derived variables at the household level referring to household size and type, equivalent size, number of persons per age class, number of persons who are working or are unemployed, etc. Therefore, four EP expenditure indicators were formed and calculated, based on previously used (e.g., the "10% rule") or modified (e.g., variations of 2M and M2 indicators) and other indicators suggested by scholars (e.g., the "25% threshold", a variation of the "FixThreshold" indicator proposed by (Menyhert, 2023).

Based on Figure 14 to Figure 17, the following remarks can be made:

- After an increase in 2018, all EP expenditure indicators decline steadily. The same pattern is observed in the consensual-based EU SILC indicators.
- According to the Low Expense, High Expense and "25% threshold" indicators, the share of the population facing EP problems is around 15%, on average. The "10% rule" seems to overestimate the EP problem (more than half of the population is characterised as EP).
- The EP levels in the area of interest, i.e., the Brezovo pilot, are higher than the national averages for all four indicators by around 11% (for the "10% rule" indicator) to more than 75% (for the Low Expense indicator).
- The gap between the pilot area and the national average is gradually narrowing for three indicators, i.e., "10% rule", High Expense and "25% threshold". Nevertheless, the gap increases for the Low Expense indicator, i.e., from 55.6% in 2019 to 76.2% in 2021.

Figure 14. Share of population whose absolute level of energy expenditures is less than half the national median.

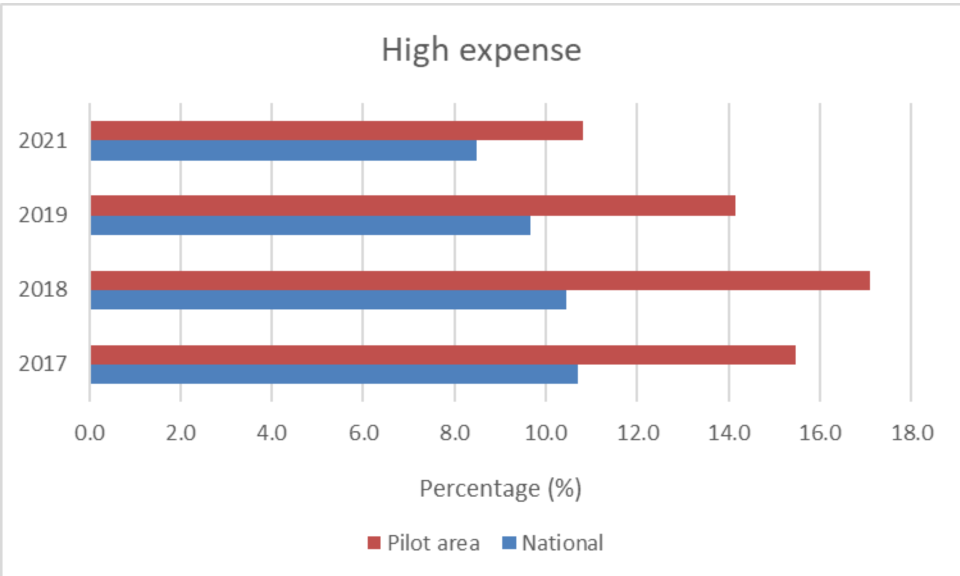

Figure 15. Share of population whose energy expenditure-to-income ratio is more than twice the national median.

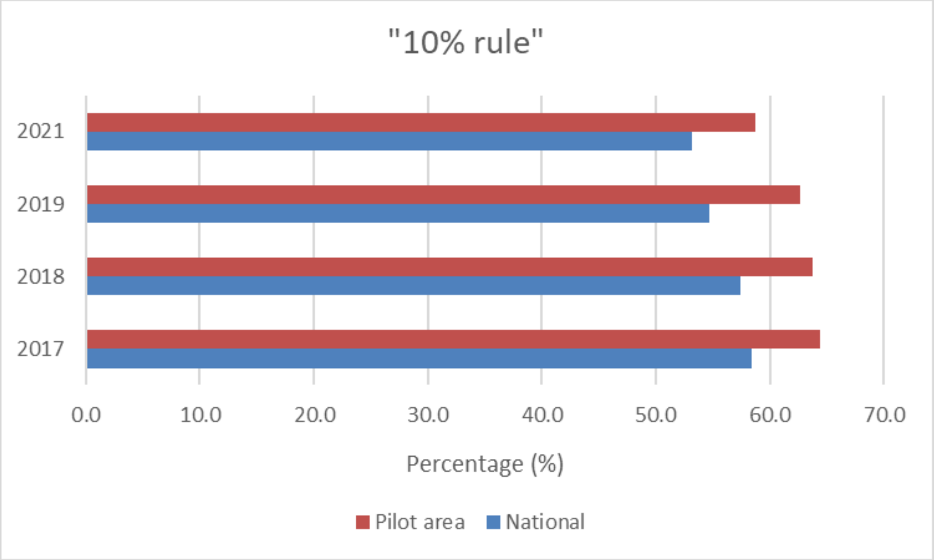

Figure 16. Share of population whose absolute level of energy expenditure is more than 10% of their income.

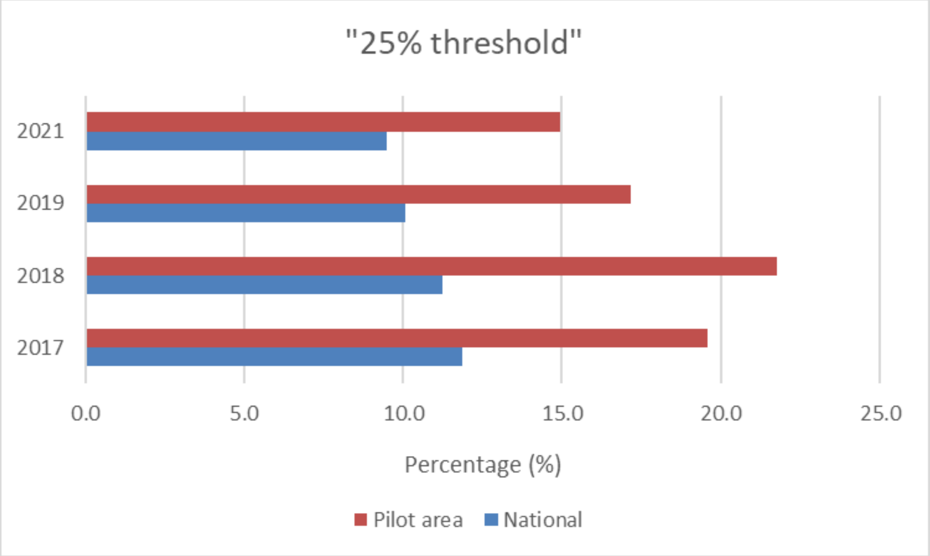

Figure 17. Share of population whose energy expenditure exceeds 25% of total expenditures.

To explore the role of income, ten different income classes were created using the median national income per year, as follows:

- Income class 1 - below 20% of the national median income
- Income class 2 - between 20% and 40% of the national median income
- Income class 3 - between 40% and 60% of the national median income
- Income class 4 - between 60% and 80% of the national median income
- Income class 5 - between 80% and 100% of the national median income
- Income class 6 - between 100% and 120% of the national median income
- Income class 7 - between 120% and 140% of the national median income
- Income class 8 - between 140% and 160% of the national median income
- Income class 9 - between 160% and 180% of the national median income
- Income class 10 - over 180% of the national median income

Moreover, because the number of observations in some income classes was relatively low, the ten income classes were grouped into three income categories, i.e., low-income households (Income classes 1 to 3, i.e., those who have income below 60% of the national median income); middle-income households (Income classes 4 to 7, i.e., those who have income between 60% and 140% of the national median income); and high-income households (i.e., those who have income over 140% of the national median income).

As shown in Figure 18 and, especially, in Figure 19, there is an unquestionable correlation between EP and income for all indicators. For example, the share of the population experiencing EP issues based on the Low Expense indicator is more than three times higher in the low-income class compared to the middle-income class, and 5.5 times higher compared to the high-income class.

Similar conclusions can be drawn from the other HBS EP indicators. Taking into account that, as a rule, low-income households live in low energy-efficient houses and, in addition, these households are unable to retrofit their houses for financial reasons, it exacerbates the problem and traps them in a vicious cycle.

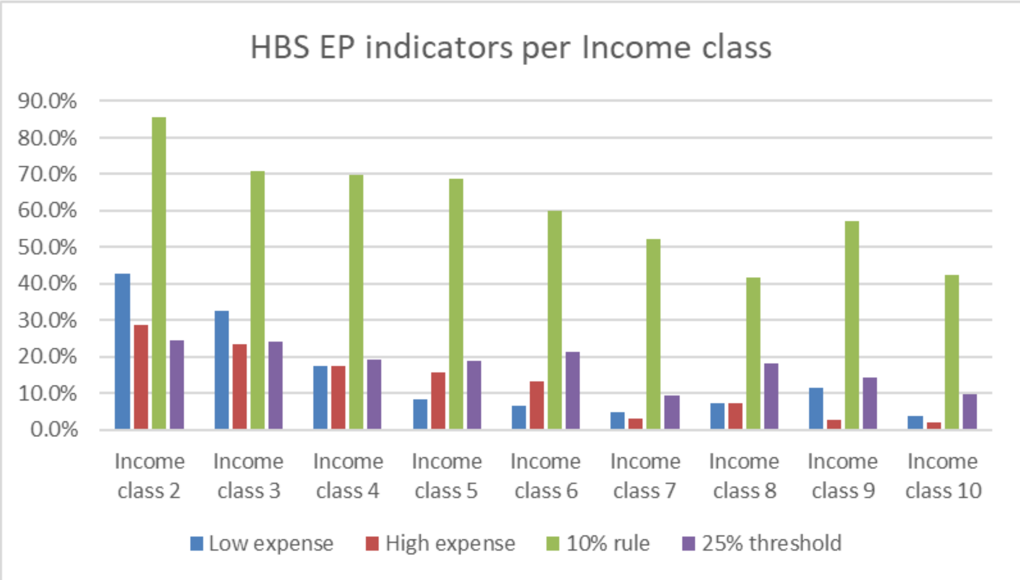

Figure 18. HPS expenditure-based EP indicators in relation to the level of income.

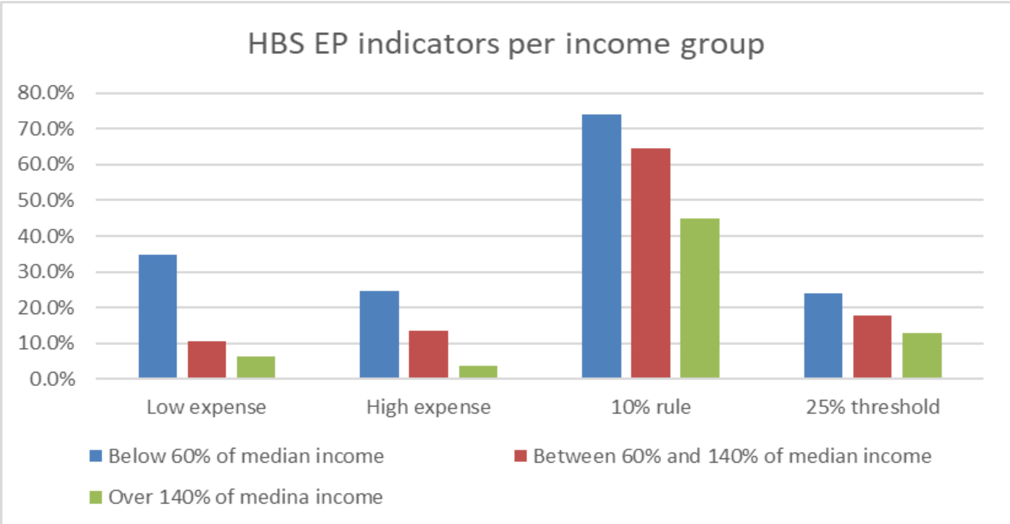

Figure 19. HPS expenditure-based EP indicators per income group.

3 Analysis of the conditions in the pilot area

3.1 Geographical position

The municipality of Brezovo is located in southern Bulgaria and is one of the constituent municipalities of the Plovdiv Region. It is located on an area of 465.41 km². The relief of the municipality is diverse - flat in the southern part, hilly in the central part and low mountainous in the northern part. The territory falls in the Upper Thracian lowland and parts of the Middle Deer Forest. The average altitude is 250 m. The lowest point is on the border with Rakovski Municipality - 171 m, and the highest is at Mount Bratan - 1235.8 m.

3.2 Climate data

The municipality of Brezovo is located in the transitional-continental climate zone - warm summers and mild winters are present. Average January temperatures are positive, while average July temperatures vary between 22-24 °C. Precipitation has a pronounced autumn-winter maximum. The annual amount is about 500 mm/m². The prevailing winds are westerly with an average annual speed of 1.1 m/s.

Characteristic for the western parts of the climatic region of Eastern Central Bulgaria, where Brezovo is located, are the mild winter with frequent warming under the influence of Mediterranean cyclones and the protective effect of Stara Planina in relation to the invasions of cold continental air, as well as hot summer with a small temperature amplitude and relatively low relative air humidity.

Seasonal precipitation amounts in the area almost equalize, with the maximum often occurring in spring and autumn, which indicates a transition to a Mediterranean-continental climate regime, more pronounced in the southern parts of the municipality. Under the influence of warm air masses, the winter is warm and mild. As a result of the rapid rise in temperatures at the end of winter, spring starts early. The average temperature in October is 2-3 ^{o}C higher than in April. The average annual temperature is 12.5 ^{o}C, and the average January temperature is 0.2 ^{o}C. The average daily temperature at the beginning of March exceeds 5 ^{o}C, and at the beginning of April, it is 10 ^{o}C.

- The average annual air temperature is 11.4 ^{o}C.
- The average annual maximum air temperature is 16.9 ^{o}C, and the minimum is 5.7 ^{o}C.
- The average monthly air temperature is 11.2 ^{o}C.
- The average monthly relative air humidity is 74%.

Precipitation depends on the characteristics of atmospheric circulation, altitude and landforms.

3.3 Demographic data

According to data from Census 2021, Brezovo Municipality has 16 settlements with a total population of 6170 inhabitants. Of these, 1,604 people live in the city of Brezovo, and the remaining 4,696 live in the surrounding villages. The predominant ethnic group is Bulgarians. There is a total of 3,241 people of working age, of which 1,839 are men and 1,402 are women. The reduction of the population in the last 10 years is clearly outlined. In numbers, it has decreased in 2021 from the previous national census in 2011 by 1128 people or 15.4%.

The conclusion of the analysis of the population census by age is that the population is ageing. As the figure below shows, the highest number of the population is occupied by people over 70 years.

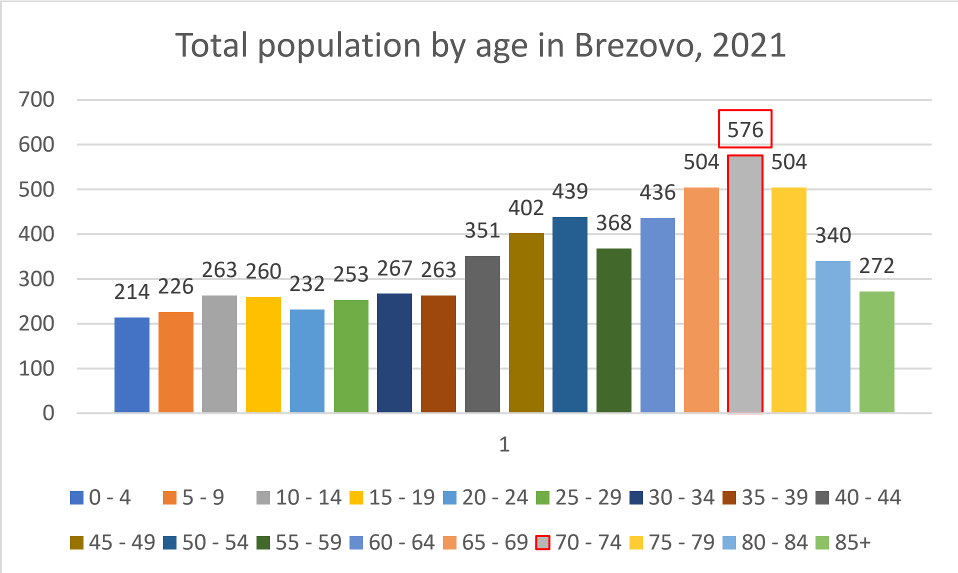

Figure 20. Total population by age in Brezovo (source: NSI).

The trend in population dynamics is characterized by a decrease in the population and, respectively, the number of households.

Table 1. Population by gender.

Population by gender						
	2002		2011		2022	
	Men	Women	Men	Women	Men	Women
Brezovo	3873	4289	3513	3690	2959	3069

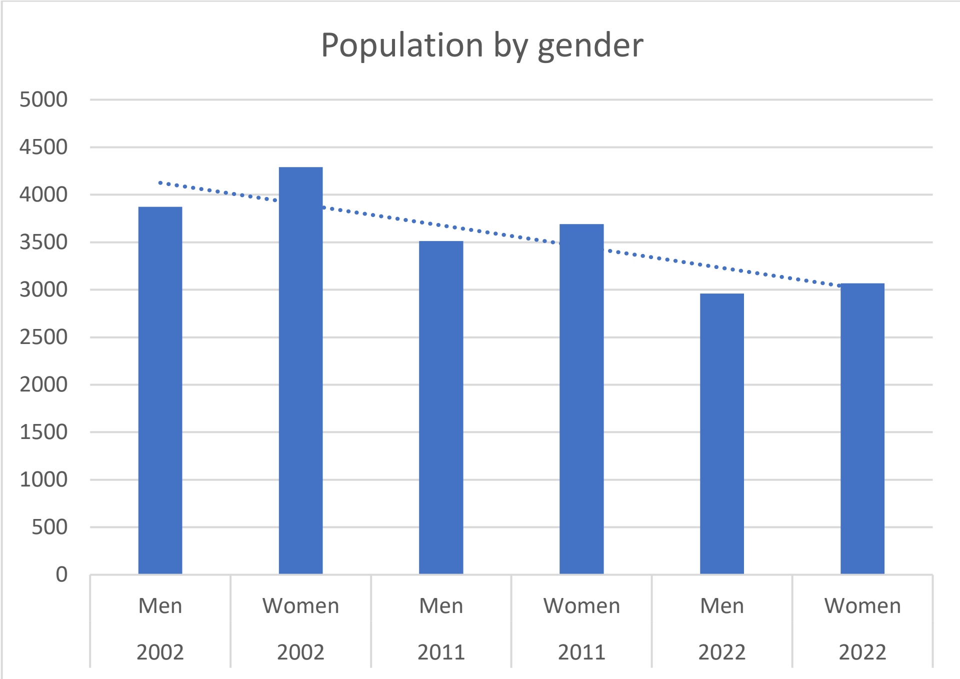

Figure 21. Population by gender.

According to the Municipal action plan for the period 2021-2023, the Municipality of Brezovo has an unfavorable socio-demographic structure. The plan states that unemployment among the able-bodied population in the municipality is 20%. This is an important economic and social problem, which probably affects many spheres of life of the people in the municipality. According to the plan, only three people found work through the Regional Employment Program. This fact may indicate limited opportunities for employment and economic development in the region, which may be a challenge to increase employment. Based on Eurostat indicators, about 30% of the population in the Municipality is below the poverty line.

3.4 Energy supply and infrastructures

The Municipality of Brezovo is securely powered by three electricity transmission lines. The first transmission line from the Chernozem substation supplies the villages of Varben, Borets, Zlatosel and Otets Kirilovo, while the settlements of Streltsi and Drangovo are supplied through the node station built in the village of Padarsko.

The backup power supply to the node station "Padarsko" is from the "Stryama" transmission line. Nodal stations "Babek" and "Brezovo" have backup power from the transmission line from the substation "Chernozem".

A total of 92 substations have been built in the territory of the Municipality. They are owned by "Elektrorazpradelenie - Plovdiv" EAD, which after privatization is owned by an Austrian company with 30% state participation. The built power transmission and distribution network ensures sufficient security and efficiency in the power supply of the municipality.

The territory of the municipality is not gasified. In 2012, an investment proposal was submitted for "Gas supply to the Municipality of Brezovo with the construction of a gas distribution network with gas pipeline diameters from Φ160 to Φ32 and length 15,000 m within the regulatory limits of Brezovo town, Brezovo municipality. In 2012, the Municipal Council of the town of Brezovo approved the Plan-scheme for the gas supply of the town of Brezovo.

No permits have been issued for the construction of biodiesel plants.

The use of other RES, such as geothermal, and bio-energies (modern biomass technologies) is still insignificant and does not affect the energy balance of the municipality. On the territory of the Municipality of Brezovo, there are no hydro-electric, biogas plants, or those utilizing waste or other biomass.

4 Analysis of the building stock

4.1 Overview of the residential building stock

The inhabitants of Brezovo occupy approx. 2,700 dwellings. The following table represents information about the total number of dwellings in a particular area or region in 2021, broken down into various categories.

Table 2. Total Dwellings by Census 2021 by category.

Total Dwellings by Census 2021					
Total	Dwelling for permanent (usual) residence	Housing for seasonal or vacation residence	A dwelling inhabited by persons who are not subject to the census (foreign diplomats, trade representatives, etc.)	The apartment is collective	The apartment is unoccupied for another reason
6,422	2,679	2,315	-	2	1,426

In 2021, there were a total of 6,422 dwellings in the Municipality of Brezovo. As can be seen from the figure below, among the total dwellings, 2,679 (42%) were used for permanent or usual residence. There were 2,315 (36%) dwellings designated for seasonal or vacation residence. According to the Census data, there were 2 apartments classified as "collective", which refer to housing units shared by multiple unrelated individuals or families. The Census analysis indicates that there were 1,426 (22%) apartments unoccupied for reasons other than being a seasonal or vacation residence. This category may include vacant properties for various reasons, such as being in the process of sale, renovation, or other non-residential purposes.

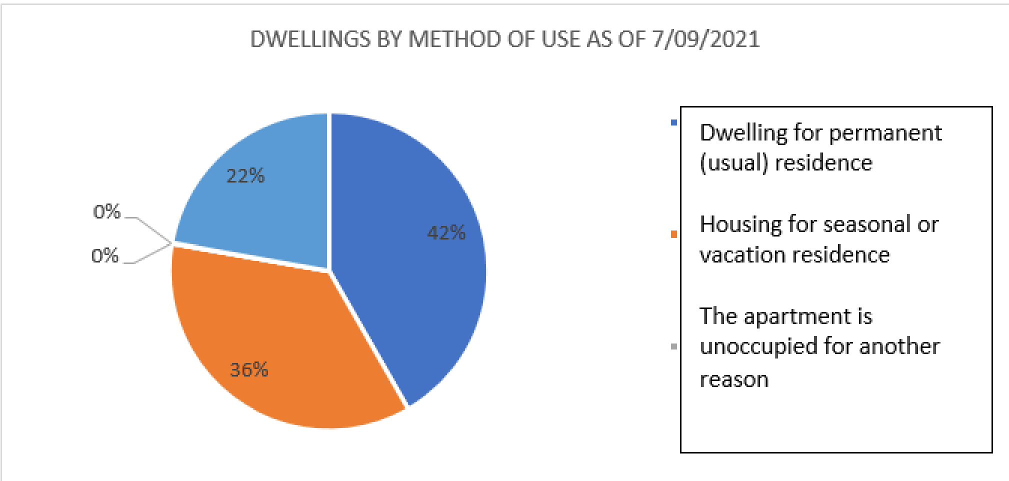

Figure 22. Dwellings by method of use as of 7/09/2021 (based on NSI data).

The total number of households in Municipality of Brezovo is 2774, which is almost close to the number of dwellings for permanent use, and the ratio of the two figures is 1,035.

Table 3. Number of households and household members.

Households and number of members as of 07.09.2021							
Number of persons in household	1	2	3	4	5	6 and more	Total
Brezovo	1098	886	341	222	116	111	2774

Single-family residential buildings predominate in Brezovo, there are only 2 multi-family buildings, which consist of 12 households per building or 24 households total, living in multifamily buildings.

About 60% of the buildings are uninhabited due to demographic and economic reasons.

Table 4. Residential buildings by type of habitat.

Residential buildings by type of habitat as of 07.09.2021			
Single-family buildings			**Multi-family buildings**
Occupied	Unoccupied	Total	
2,679	3,777	6,326	2

For the roadmap, it is assumed that the number of single-family residential buildings is 2,679.

Regarding the period of construction, more than 66% of the buildings were built before 1959.

Table 5. Residential buildings by periods of construction.

Residential buildings by periods of construction as of 09.07.2021							
	Until 1959	1960 - 1969	1970 - 1979	1980 - 1989	1990 - 1999	2000 - 2009	2010-2021
Brezovo	4262	621	540	575	301	114	85

Changes in population size, age demographics, or migration patterns may have influenced the demand for housing during specific time frames.

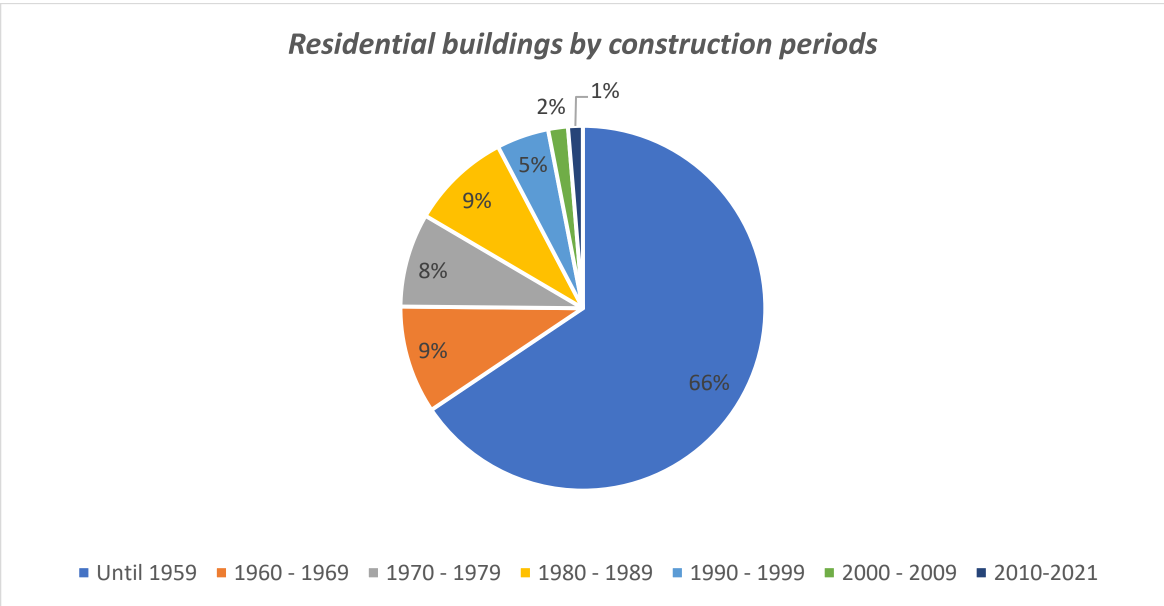

Figure 23 Residential buildings by construction periods

The following table details residential buildings in Brezovo Municipality in 2021, categorized by the type of construction and basic materials used.

Table 6. Residential buildings according to the type of construction and basic material used.

	Residential buildings according to the type of construction and basic material used (2021)								
	Brick with concrete slab	Brick with joists, without reinforced concrete	Reinforced concrete structure with slab and columns	Loam	Stone	Wooden	From panels (ready-made prefabricated elements)	Assembled from metal structures	Other
Brezovo	1089	2405	65	2732	46	52	14	2	93

The dominance of brick constructions, both with concrete slabs and joists (without reinforced concrete), signifies a reliance on traditional building materials and methods in the region. This is typical of the region's historical construction practices and the availability of locally sourced materials.

The table shows the predominant use of loam for house building (42%), due to the age of the buildings.

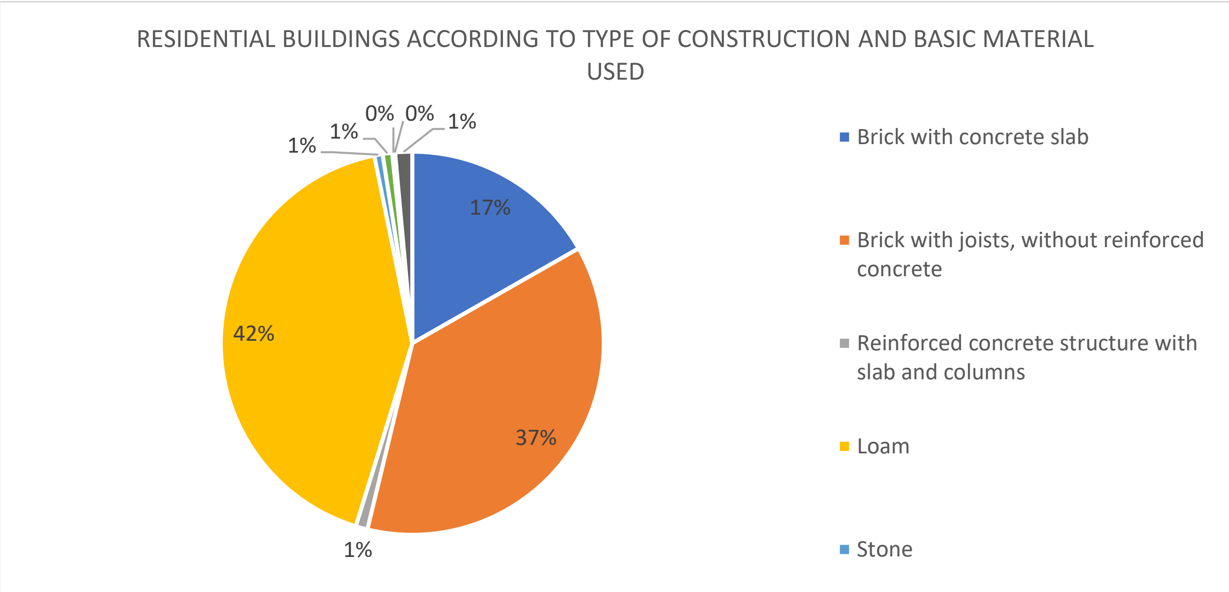

Figure 24. Residential buildings according to the type of construction and basic material used.

The majority of dwellings are private single houses with low levels of efficiency (>95%). In 2019, the final energy consumption of the Municipality was estimated at 44.85 GWh. The housing sector is responsible for 26.64 GWh of the total energy consumption, taking the largest share or 59.4%. The use of raw wood for domestic heating is dominant (47%), followed by electricity (39%) and coal (12%). This is a prerequisite for high PM pollution during the heating season. The housing sector is responsible for 10,247 tons of greenhouse emissions. The technical potential of the possible recovery of the waste streams from the agricultural sector and animal waste is calculated for the production of 5,900 MWth. The Municipality is also rich in forestry. Residual biomass from logging is equal to 7,460 tons of wood, whose energy equivalent is equal to 38,250 MWh of heat.

The results from the National Census show that 74% of the dwellings in Brezovo have no renewed windows (Figure 25), and 91% of the dwellings are without insulation (Figure 26).

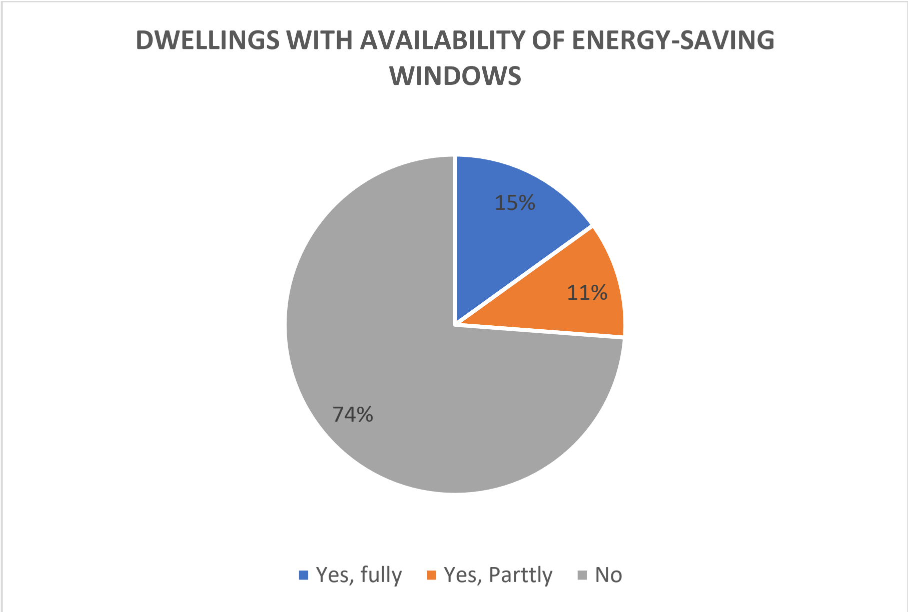

Figure 25. Dwellings with availability of energy-saving windows as of 09/07/2021 (Source: https://infostat.nsi.bg/).

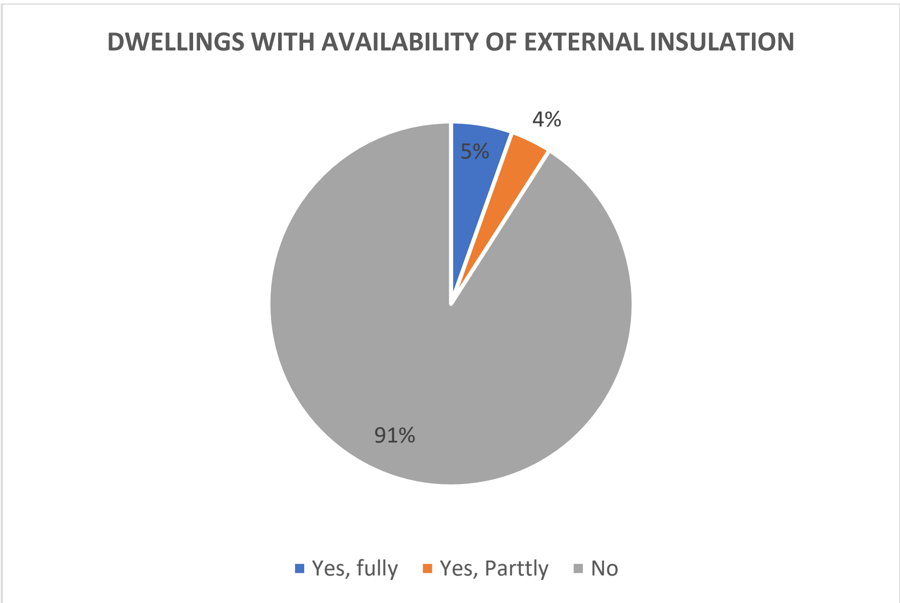

Figure 26. Dwellings with availability of external insulation as of 7/09/2021 by the National Census 2021.

According to the Municipal Energy Efficiency Program, the residential sector of the municipality of Brezovo occupies the largest percentage of the municipality's final energy consumption – 59.4%, consuming a total of 26.6 GWh of energy.

Looking at the percentage of energy sources used, the dominant use is the use of raw wood for domestic heating (47%), followed by the consumption of electricity (39%) and coal (12%). Heating is based mostly on the use of wood and coal and a minor share of electricity. The high levels of use of wood and coal are a prerequisite for influencing the air quality.

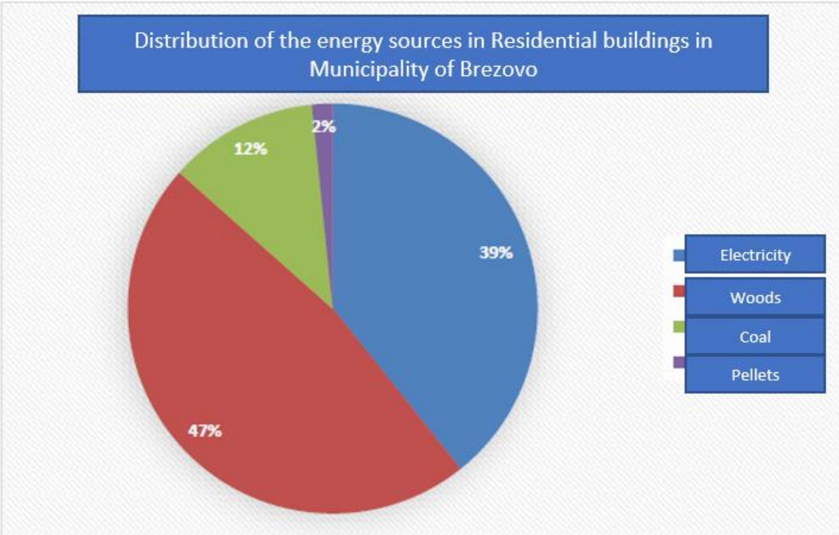

Figure 27. Distribution of energy sources in residential buildings in Municipality of Brezovo (Source: Municipal Energy Efficiency Program).

4.2 Information about the energy demand and the utilized fuels per building type

In the long-term national strategy to support the renewal of the national building stock of residential and non-residential buildings until 2050, a review was made of technical systems and energy carriers in residential buildings, which shows that the main energy consumption in residential buildings is the heating consumption - almost 80% of the energy determined according to the baseline and 64% of the actual energy consumption. The analysis shows that the value of the actual energy consumption for heating is approximately two times lower than that required to reach the normative parameters of the microclimate in the existing condition of the buildings (before renovation). The main reasons for this are the presence of unoccupied dwellings (more than 20% of dwellings in inhabited buildings), the unheated common parts of residential buildings and the maintained low average volume temperatures of conditioned spaces. **This is one of the specifics of the housing stock in Bulgaria, a result of the demographic situation in the country, the disproportions in the territorial distribution of the population and the depopulation of some areas, such as Brezovo Municipality.**

The review of energy consumption by energy source shows that it is unbalanced, with a significant share of non-ecological/cheap energy sources.

According to the Municipal Energy Efficiency Program, the residential sector of the municipality of Brezovo occupies the largest percentage of the municipality's final energy consumption – 59.4%, consuming a total of 26.6 GWh of energy. Looking at the percentage of energy sources used, the dominant use is for raw wood for heating (47%), followed by the consumption of electricity (39%) and coal (12%). Heating is based mostly on the use of wood and coal and a minor share of electricity. The high levels of use of wood and coal are a prerequisite for influencing the air quality in Brezovo.

Table 7. Number of residential buildings.

Total number of residential buildings	*Number of households using woods and coal for heating*	*Number of households using wooden pellets for heating*	*Number of households using electricity for heating*
2710	2249	54	407

Table 8. Final energy consumption by energy source.

Energy Source	Final energy consumption MWh/y	Distribution of the energy sources in Residential buildings, %
Electricity	10466,3	39,3%
Woods	12594,4	47,3%
Coal	3148,6	11,8%
Pellets	432	1,6%
Total	26641,3	

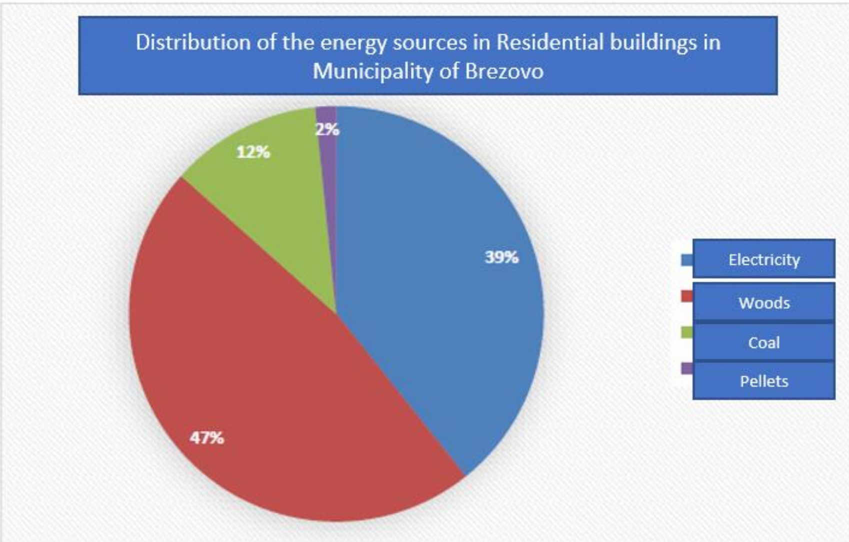

Figure 28. Distribution of energy sources in residential buildings in Municipality of Brezovo (Source: Municipal Energy Efficiency Program).

According to the Institute for Energy Management in Bulgaria, traditionally, the final energy consumption of households is mainly covered by electricity (41%) and renewable sources and biofuels (36.1%). It has been repeatedly noted that behind this high share of RES in households, the main contribution is the use of wood for heating and hot water. Unlike the average values for the EU, the consumption of natural gas by Bulgarian households is extremely low (4%).

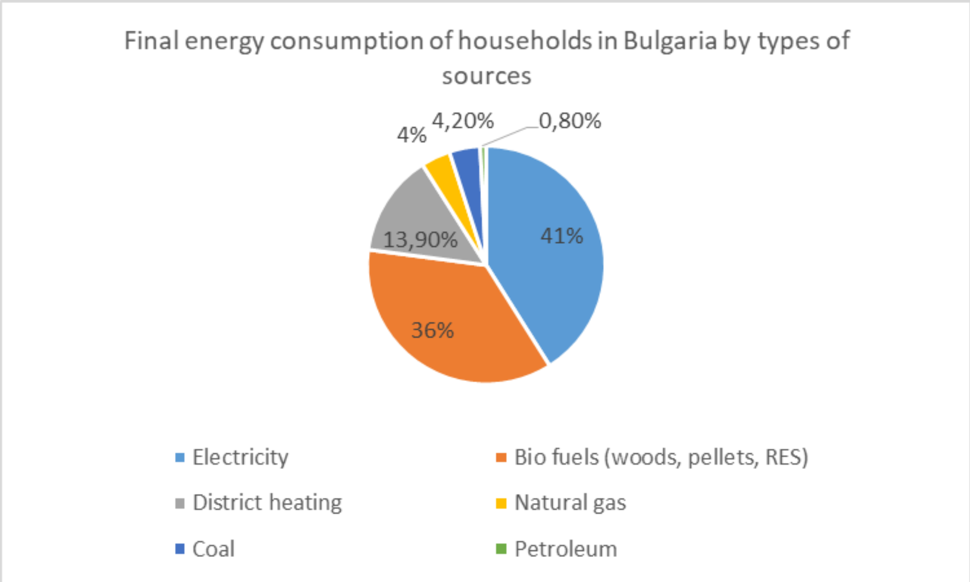

Figure 29. Final energy consumption types of energy source (Source:EMI).

The statistical data of Eurostat for Bulgaria regarding the distribution of energy by satisfied needs and by energy sources is presented in the figure below.

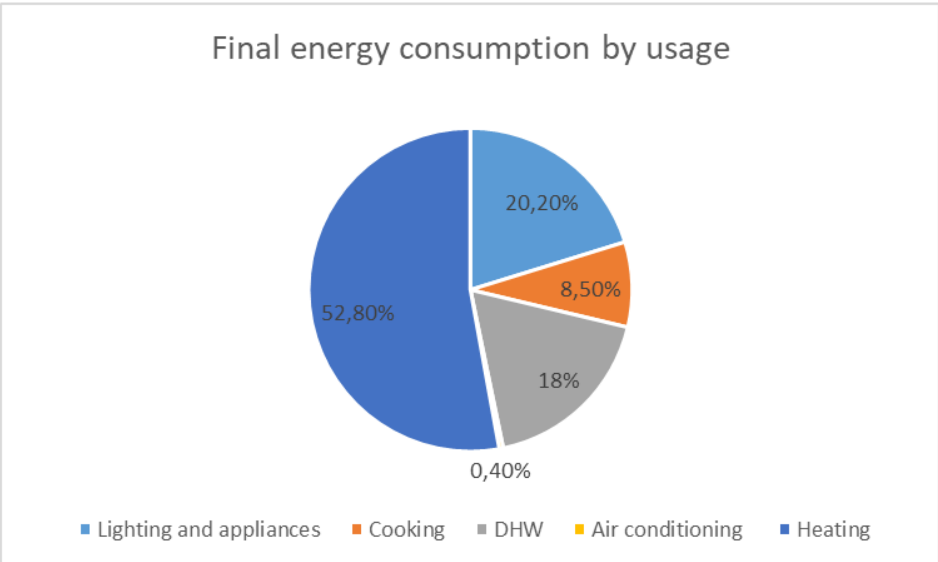

Figure 30. Distribution of energy by usage (Source: Center for Energy Efficiency EnEffect).

The distribution of electricity consumption in households by needs is presented in Figure 31.

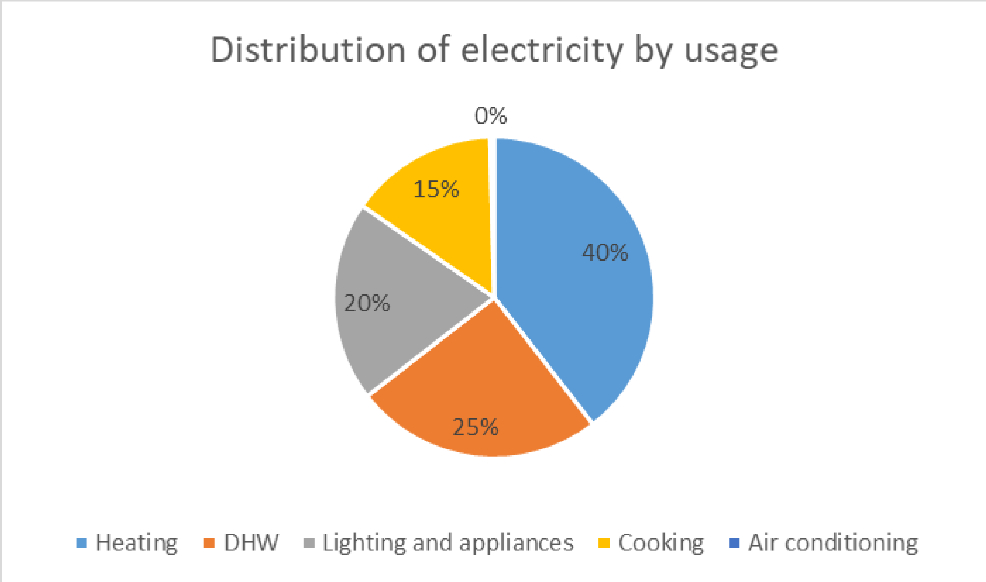

Figure 31. Distribution of electricity consumption in households by needs (Source: Center for Energy Efficiency EnEffect).

According to the type of heating, the number of heated households is as follows:

• Wood/coal – 2249

• Pellets – 54

• Electricity – 407

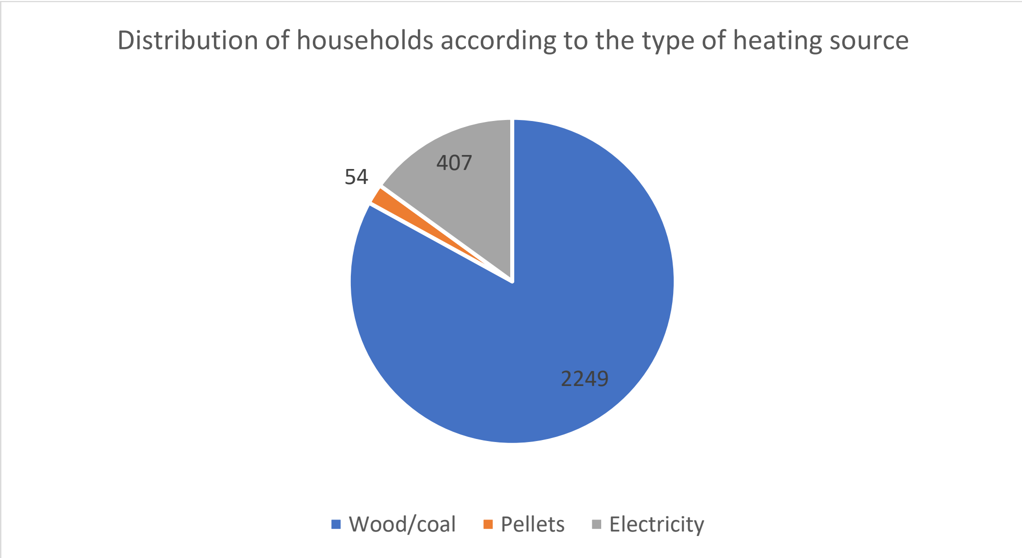

Figure 32. Distribution of households according to the type of heating source.

Table 9. Final energy consumption for heating in households.

Final energy consumption for heating in households	
Energy source	**MWh**
Wood	12594,4
Coal	3148,6
Pellets	432
Electricity	1480
Total for the sector	**17655**

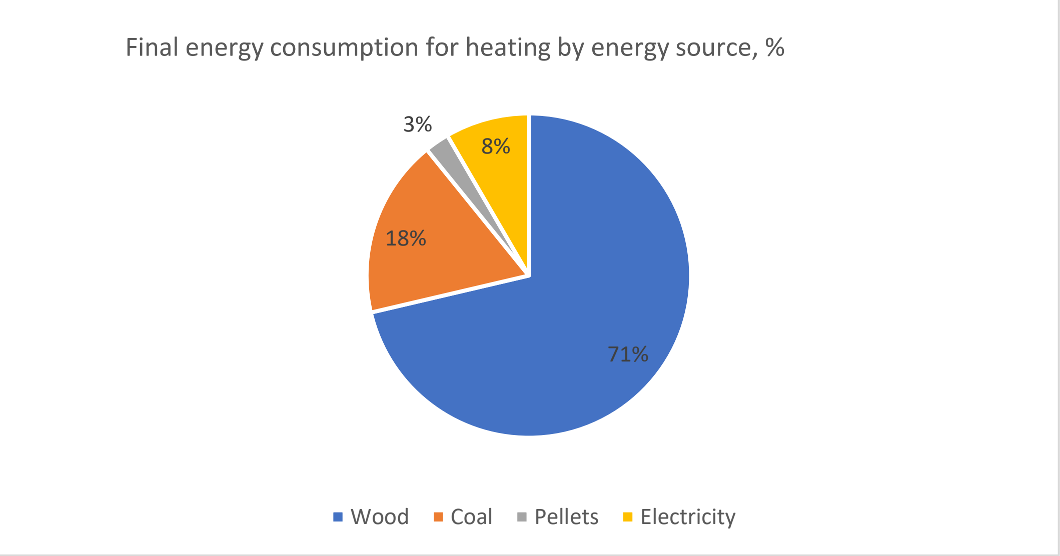

Figure 33. Final energy consumption for heating by energy source, %.

The following table provides a comprehensive overview of final energy consumption, primary energy consumption, and CO_2 emissions generated by different energy sources in the households.

Table 10. Calculation of final and primary energy consumption and CO_2 emissions generated in residential buildings.

	Final energy consumption	Primary energy consumption		CO2 emissions generated	
Energy source	**MWh**	**Factor**	**MWh**	**Factor, gCO_2/kWh**	**tCO_2/MWh**
Woods	12594.4	1.2	15113.28	40	604.5
Coal	3148.6	1.1	3463.46	360	1246.8
Pellets	432	1.2	518.4	40	20.7
Electricity	10466.3	2.5	26165.75	486	12716.6
Total	26641.3		45260.89		14588.7

4.3 Analysis of the energy poverty levels per building type

To explore whether certain housing characteristics and households' living conditions are related to EP vulnerability, the difference in EP rates of the investigated indicators relative to their average rate in the pilot area was examined.

As illustrated in the figure below, households living in large buildings are less prone to arrears and more capable of keeping their apartments adequately warm compared to those living in small buildings, detached or semi-detached houses. Also, those living in small buildings face higher problems with leaks. These findings can be related to the fact that a large part of detached houses was built before the introduction of national energy efficiency legislation, while a large part of multi-family residential buildings was built after 1960, when the first norms and requirements for energy efficiency were introduced.

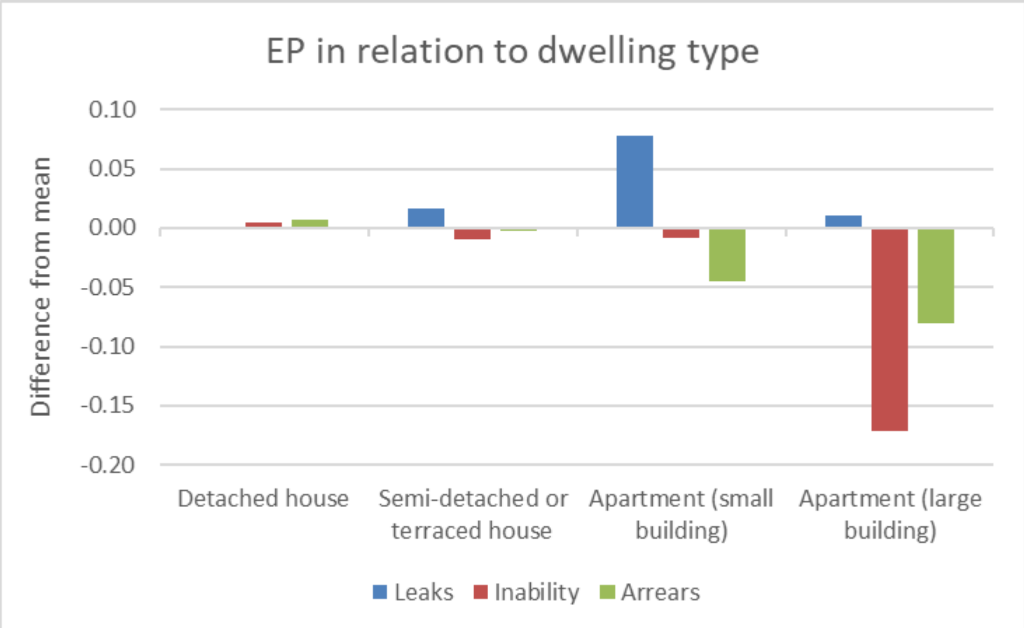

Figure 34. Leaks, inability to keep house warm and arrears on utility bills in relation to dwelling type.

The size of the house is also associated with the three basic EP indicators, according to Figure 35. Those living in one- or two-room houses have higher EP rates compared to the average, while those living in houses with four or more rooms have lower EP rates. Again, the most likely explanation for this result is the difference in income. For example, the average income of the households that live in one- or two-room houses ranges between 3,200-4,200 EUR, while the average income of the households living in houses with more than four rooms is more than 9,500 EUR, on average.

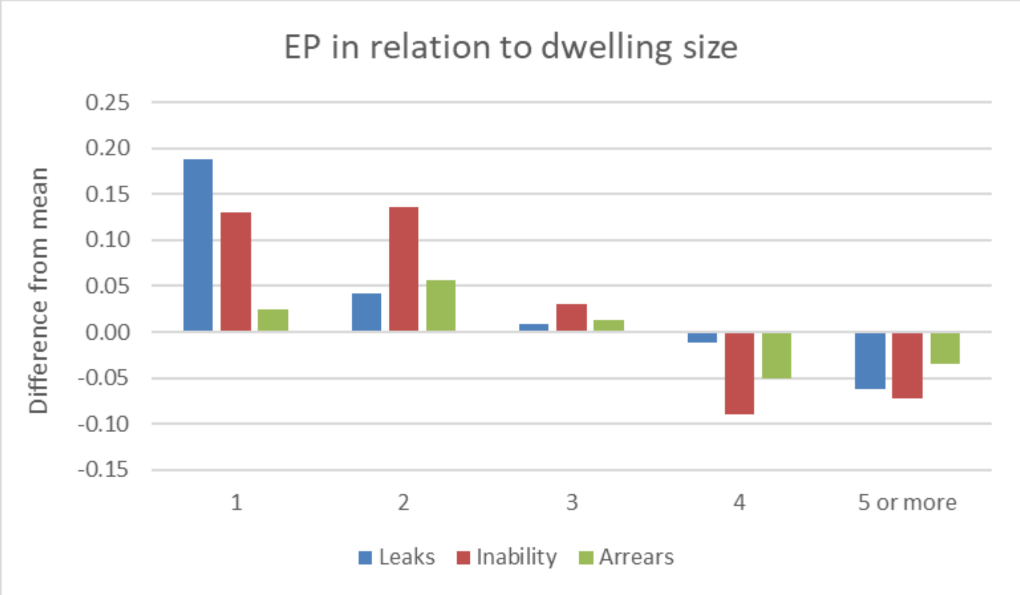

Figure 35. Leaks, inability to keep house warm and arrears on utility bills in relation to dwelling size.

As far as tenure status is concerned, the most vulnerable groups to EP are tenants who pay rent (either at the market or at a reduced rate). These results should however be viewed with caution because the number of observations in these categories is very small (less than 15).

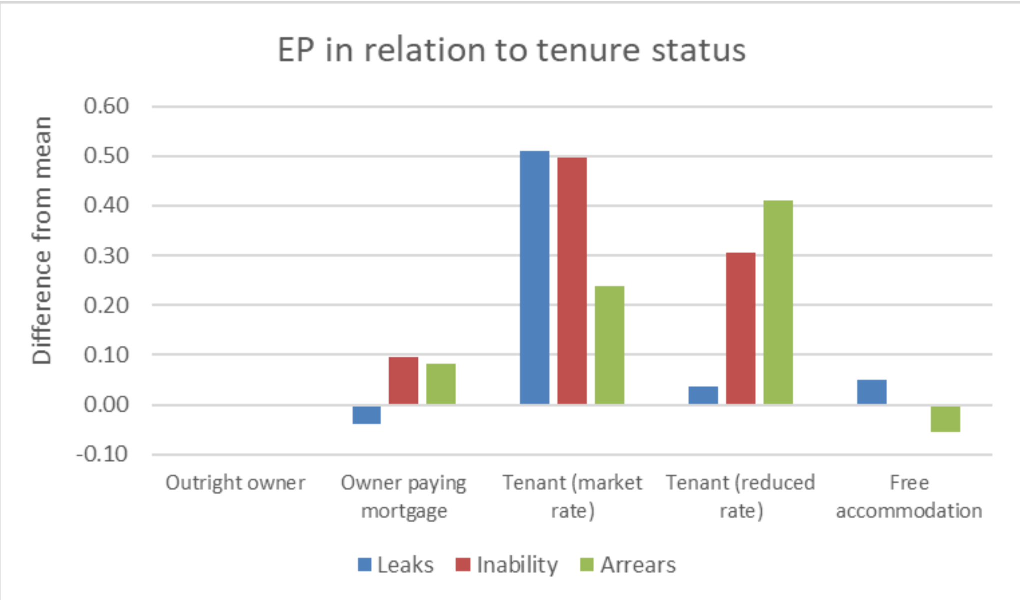

Figure 36. Leaks, inability to keep house warm and arrears on utility bills in relation to tenure status.

The role of income in energy poverty becomes evident in Figure 37. Households experiencing great difficulty in making ends meet have differences in EP rates of up to 30% compared to the average rates. On the contrary, those who can pay easily for their usual necessary expenses have quite lower EP rates (e.g., differences from the average of more than 30% in the ability to keep their houses warm).

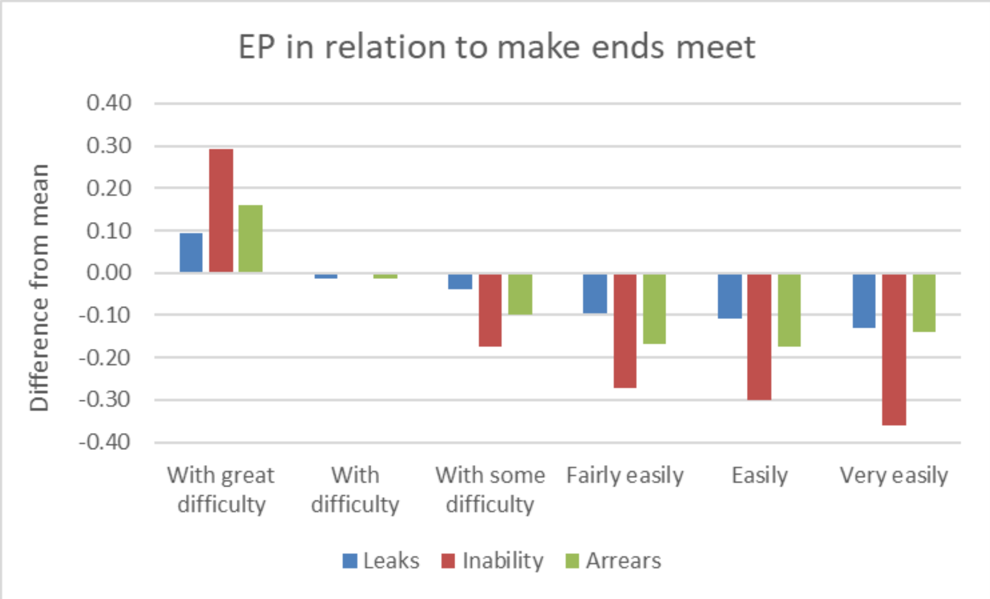

Figure 37. Leaks, inability to keep house warm and arrears on utility bills in relation to the level of difficulty in making ends meet.

The above-mentioned patterns are observed, and are even more pronounced, in the complementary EP indicators. For instance, in Figure 38, households living in small buildings are more energy-vulnerable, while the opposite is true for those living in large buildings. Tenants (Figure 40) and those living in one- or two-room homes (Figure 39) are also more energy vulnerable. Finally, those who find it difficult to make ends meet present scores, in all EP indicators, higher than the average, while those who live comfortably score lower than the average (Figure 41).

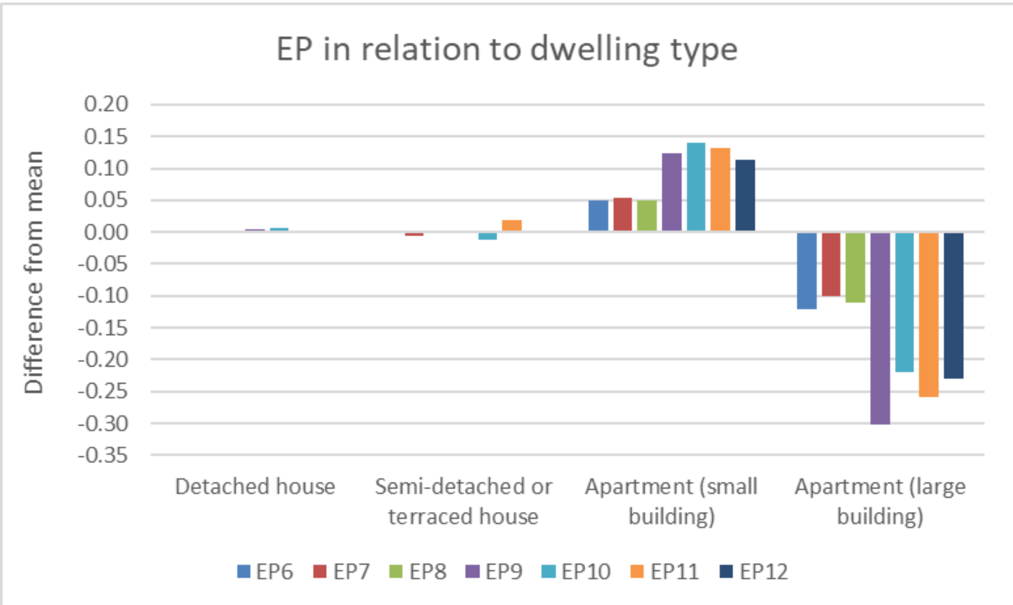

Figure 38. Complementary EP indicators in relation to dwelling type.

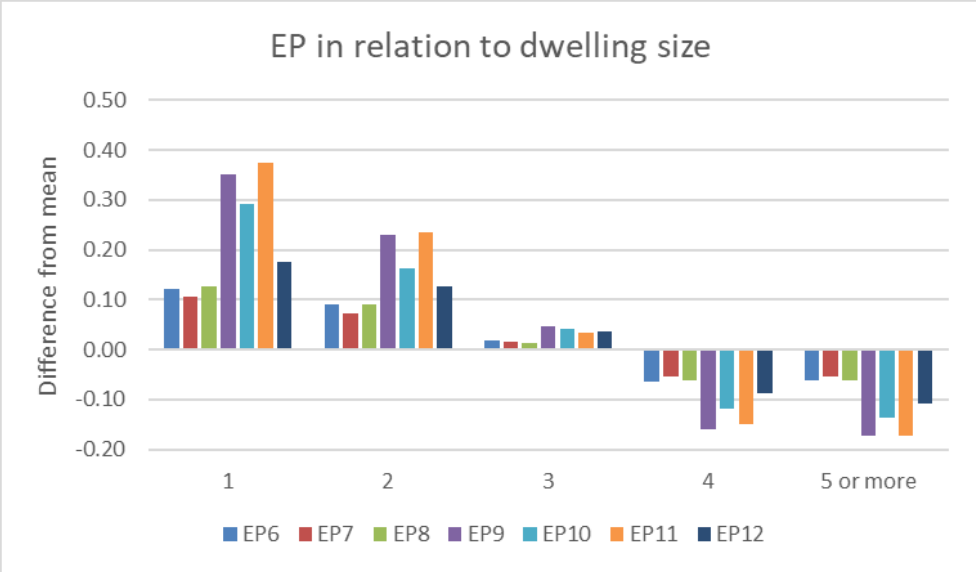

Figure 39. Complementary EP indicators in relation to dwelling size.

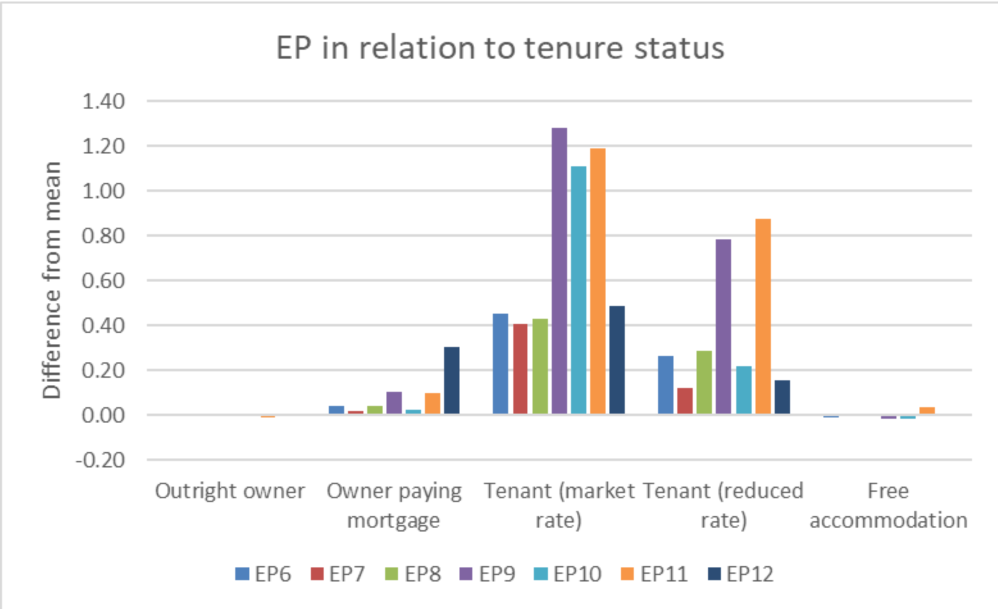

Figure 40. Complementary EP indicators in relation to tenure status.

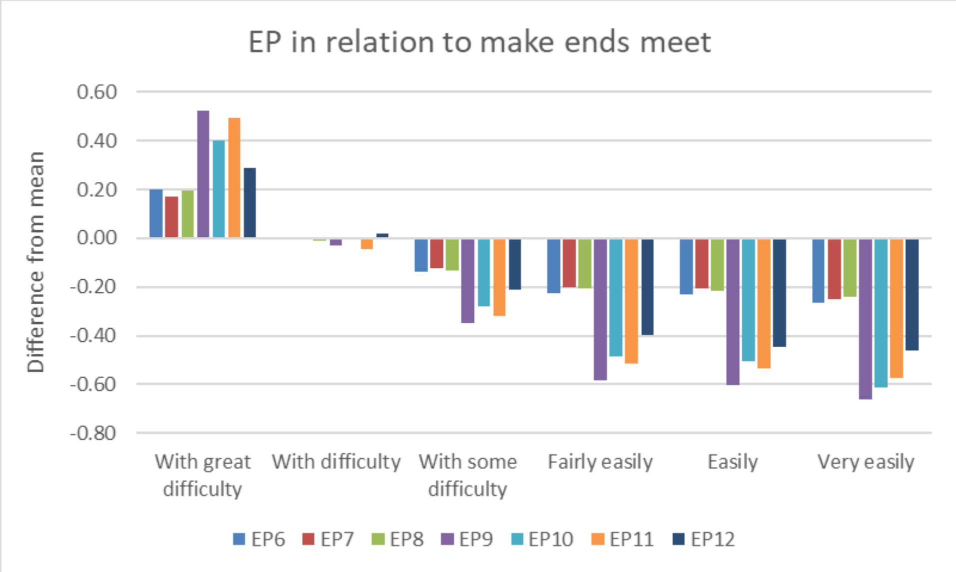

Figure 41. Complementary EP indicators in relation to the level of difficulty in making ends meet.

4.4 Identification and analysis of existing policies, strategies or investments planned for the pilot area so as to renovate the building stock

Currently, there exists only one national programme, namely the **"Support for Sustainable Energy Renovation of the Residential Building Fund"** (total investment: BGN 1,176,960,000.00), aiming at providing financial, organisational and technical assistance to improve the energy performance of the housing stock in the Republic of Bulgaria. The programme will run between 2023 and 2027 and has introduced a financial scheme in support of sustainable energy renovation of residential buildings. According to the previous procedure, which represented the first stage of the implementation of the sub-measure "Support for sustainable energy renovation of the housing stock", for proposals implemented under the conditions of the "non-aid" regime, co-financing is not required from the final recipient of the funds - aid intensity was 100%. In the second stage of the implementation of the sub-measure "Support for sustainable energy renovation of the residential building stock", which is a subject of a separate procedure, the final recipients will be required to co-finance 20% of the amount of eligible costs under the project. The criteria for the proposals to be approved require that the buildings reach energy consumption class minimum B after applying energy-saving measures; that the measures stimulate a minimum of 30% primary energy savings, implement resource efficiency, economic expediency, decarbonisation through RES, sustainable construction process, reduce energy poverty by reducing energy costs, and ultimately, improve the conditions and quality of life of the population in the country through technological renewal and modernization of the building stock.

More information: https://eumis2020.government.bg/bg/s/Procedure/Info/fbf34c6a-8f67-4d16-9019-3bd43c71b70f

As far as the support of RES installation is concerned, the Republic of Bulgaria has established the **"National scheme to support households in the field of energy from renewable sources"**, under the "National plan for recovery and sustainability of the Republic of Bulgaria". This scheme aims to support households in the field of energy production from RES, so as to promote the decentralised production of energy from RES, stimulate the consumption of ecologically clean energy, and reduce the consumption of solid fuels in the household sector. It provides financing for the purchase of solar installations for domestic hot water supply (DHW) and the purchase of photovoltaic systems up to 10 kWp, including electrical energy storage systems. The total amount of the financial scheme is BGN 80 million, where each proposal can receive up to 100% of the value of the installation, but no more than BGN 1,960 for the purchase of solar installations for DHW, and up to 70% of the value of photovoltaic systems up to 10 kWp including the electrical energy storage systems, but not more than BGN 15,000.

More information: https://www.me.government.bg/themes/startira-kandidatstvaneto-na-domakinstvata-za-finansirane-na-fotovoltaichni-sistemi-2454-1639.html

The **Energy Efficiency and Renewable Sources Fund** finances investment projects for energy efficiency, aims to reduce greenhouse gas emissions in the atmosphere, and supports the development of the market for energy efficiency projects in Bulgaria. The fund was initially capitalized entirely with grant funds. The main donors are the UN Global Environmental Fund, through the International Bank for Reconstruction and Development (World Bank) - with 10 million US dollars, the Government of Austria - with 1.5 million euros, the Government of Bulgaria - with 3 million BGN and private Bulgarian sponsors. The Energy Efficiency and Renewable Sources Fund encourages applications from individuals. A necessary condition for a successful application to the "Energy Efficiency and Renewable Sources" fund is the availability of a detailed energy survey, enabling energy analysis and selection of energy-saving measures. All energy efficiency projects approved and supported by the "Energy Efficiency and Renewable Sources" Fund (FEEVI) must meet the following requirements:

- The project must implement established technology;
- The value of the project must be between BGN 30,000 and BGN 3,000,000;
- The equity participation of the borrower must be no less than 10%; Loan repayment term is up to 10 years.

More information: https://www.bgeef.com/bg/

Projects for the implementation of energy efficiency measures in residential buildings will be able to be financed under the **Regional Development Program 2021-2027** (RDP) through the European Regional Development Fund (ERDF).

An obligatory condition for the implementation of the measures for the renovation of residential buildings will be the presence of a prepared survey for energy efficiency and a technical survey of the building, and in relation to the set national goals, measures with which the building achieves a high energy class will be supported. Under the new PRR, it is planned to finance energy efficiency measures for both single-family and multi-family residential buildings, but it is not planned to finance independent measures and partial renovation measures, but activities for the complete energy renovation of the building. Measures in the area will be implemented within the framework of the two main priorities: Priority 1 "Integrated urban development" and Priority 2 "Integrated territorial development of the regions", and the eligible activities include a wide range of interventions, among which: all types of energy efficiency measures, structural strengthening, heating and air conditioning systems, integrated on-site renewable energy installations, energy storage equipment, electric vehicle charging equipment, digitalization of buildings, etc.

More information: https://www.eufunds.bg/bg/oprd/node/12208

5 PESTEL analysis

A PESTEL analysis was conducted to identify the most important parameters and the main market barriers and market failures (administrative, financial, technical, awareness and others) in the pilot area.

The PESTEL analysis consisted of the following steps:

- Step 1: Speculate the PESTEL factors
- Step 2: Identify and map all the relevant PESTEL factors
- Step 3: Assess the level of impact of PESTEL factors
- Step 4: Identify opportunities and threats
- Step 5: Select the most effective policies and measures

The PESTEL analysis concluded that the current policy developments at the national and European levels constitute a meaningful driver to foster the energy renovation of the residential buildings in Bulgaria. More specifically, the ambitious building renovation target within the NECP at the national level for 2030 and the adopted long-term strategy for the renovation of the building stock will enable the implementation of targeted policy measures in the residential sector. The current programme for the renovation of the residential buildings should be considered as the fundamental basis for the implementation of energy efficiency interventions, while the centrally designed and implemented building renovation policies and measures will facilitate the coordinated and more effective implementation of the foreseen policy measures. Moreover, the promotion of PV systems in buildings for auto consumption through the conduction of targeted policies and measures will mobilise the further penetration of RES along with energy efficiency measures. Finally, the improvement and simplification of the existing renovation programmes are imperative to become more effective.

The sufficient availability of lending funds from the banking sector and the imposition of more realistic requirements to provide the necessary lending funds to the households are considered the main economic factors for the energy renovation of residential buildings. The high interest rates, the limited access to loans and the difficulty for households to provide their own funds for implementing the required renovation interventions constitute the main barriers hampering the further renovation of the residential buildings. The notable increase in the cost of living and energy expenses due to the energy crisis and the increased levels of energy taxation hinder the implementation of energy efficiency interventions. Nevertheless, the interest and willingness to renovate their buildings have increased considerably to address the triggered impacts by the energy crisis creating a high demand for energy efficiency interventions. The uncertainty about the economic development in the future and the lack of stability due to various economic factors pose additional concerns leading to the postponement of the investment decisions. Finally, the materialization of energy efficiency interventions will trigger positive impacts on the Bulgarian economy (e.g., increased GVA, reduced unemployment) due to the considerable growth of the construction sector.

The deterioration of the energy poverty due to the high energy prices and the increased inflation has created significant social problems highlighting the urgent need to address them. Moreover, the low level of awareness and knowledge about energy efficiency issues has been identified as a main obstacle. Nevertheless, the continuously increased understanding and acceptance of prosumerism and community-based energy are considered as additional enabling factors fostering the renovation of residential buildings.

The further promotion of technological solutions in buildings is essential due to the limited digitalization of the energy sector and the low penetration of smart meters. Nevertheless, the high penetration of RES technologies can boost the technological improvement of the energy sector.

The building sector is characterized by a considerably high RES and energy efficiency potential contributing to the achievement of environmental targets. The limited environmental restrictions during the renovation and the lack of knowledge for adapting buildings to climate change have been identified as barriers to minimising the environmental performance of the building sector. Finally, the low resistance and preparedness towards future pandemics and energy crises should be addressed appropriately ensuring the continuous renovation of the residential buildings.

The adoption of the required legislative and regulatory framework for all energy-related issues will facilitate the achievement of the imposed renovation targets along with the implementation of the policy measures as foreseen within the framework of the National Energy and Climate Plan and the long-term strategy for the renovation of the building stock.

Finally, the renovation of the buildings should be reinforced with the update, simplification and optimization of the related to the building sector legislative and regulatory framework.

Table 11 presents the factors that affect the preparation of the single-family buildings renovation roadmap.

Table 11. Identification and assessment of the factors, which affect the SFB renovation roadmap.

	External factors to consider	Negative or Positive aspect	Factors affect SFB roadmaps	Importance to the renovation roadmap (High-medium-low)
	Policy goals/specified national targets (e.g., in energy, environment, regional development)	(+)	The strategic goals are synchronized with the EU's energy efficiency goals and are based on European strategic documents, European and national legislation on energy efficiency	Medium
		(+)	Exemplary cost-effective packages of measures are proposed for different levels (light, medium)/stages of energy renovation for each of the categories of residential buildings	Medium
	Governance structures (e.g., formal or non-formal structures that supports governance	(+)	Good ogranisation structure of the municipality The management structure in the municipality is structured in general and specialized departments and units carry out management, organization and coordination and control in the respective areas of work.	High
	Incentives/financial Measures	(-)	The buildings with priority for financing for renovation are mainly multi-family residential buildings, but in the Municipality of Brezovo single-family houses predominate	High
		(-)	Limited access to finance: insufficient market mechanisms to finance major renovation measures at the local level	
	Political stability and remuneration framework	(-)	Lack of political stability - The political crisis in recent years and the non-formation of a constructive government have influenced all structures and industries, and especially all citizens of Bulgaria. There are no conditions for making decisions at the national and local level	High
		(-)	Lack of predictability and long-term planning of renewal programs, which makes it difficult for stakeholders - business, owners - to plan.	Medium
Economic	*Competitiveness*	(+)	The development of technologies related to energy efficiency will have a positive effect on the local economy and its competitiveness. At the moment it is at a low level.	Low
	Cost of living	(-)	Financial inability of homeowners to undertake energy efficiency renovations themselves due to low-income levels, generally, compared to the level of initial investment required for a major renovation.	

		(-)	High inflation increasing the cost of living	High
	Energy prices	(-)	High energy prices	High
	Skilled energy efficiency professionals	(-)	There is a lack of professionals related to EE and RES in the region	Medium
		(+)	New jobs - investments in energy efficiency can create jobs in the industry that produces the relevant products and services, and the energy savings achieved to reduce the consumption of energy products in the long term	Medium
	Financing renovation interventions	(-)	The own contribution by the energy-poor households can not be guaranteed in the National program for the renovation of buildings - Higher funding rates are required.	High
		(-)	There is a lack of EE schemes in the local level and measures to promote heating from economically efficient and environmentally friendly sources	High
		(-)	There is a lack of incentives to meet the nZEB requirements	Medium
	Energy expenses	(-)	Relatively high price of the EE services and high cost of innovative technologies	High
	Benefits	(+)	Increasing the value of buildings - Major renovation of buildings increases the value of the properties in them, as it makes them more sustainable, with a better appearance and increases their life.	Medium
		(+)	(+) energy renovation leads to a reduction in household energy costs, which increases their family wallet	High
	Social and Institutional capacity	(-)	Local policy makers are not aware of social innovation in terms of citizen engagement	Medium
		(-)	Still lack of One Stop Shop for building renovation in place, which can increase the social trust and social awareness among citizens	High
		(-)	Lack of socio-economic studies of the effects of building renovation, incl. the wider benefits	Medium
		(+)	There is a developed and operating Social Service "Assistant Support"	High
	Demographics	(-)	Continuous reduction of the population in the region	Medium
		(-)	Continuous ageing of the population in the region	Medium
	Rates and characteristics of energy poverty in the population	(-)	Huge level of energy poverty in the region	High
	Level of awareness on delivered impacts by RES and energy efficiency	(-)	Low level of awareness among end users.	High
		(-)	There is a lack of trust in the energy service providers	Medium
		(-)	There is a lack of interest in issuing energy and technical audits for single-family houses	Medium

		(-)	Inefficient spending of the targeted social aid for heating – there is no control and monitoring of how it is spent.	High
	Lifestyle factors	(+)	Increasing the energy efficiency of households leads to several social benefits, including reflects on household income, energy poverty reduction and people's health.	High
	Social residence towards RES	(-)	There are no specific rules for the creation and functioning of energy communities and for the role of aggregators.	Medium
	Building maitenance	(-)	There is a lack of systematic maintenance of residential buildings leads to increasing the cost of renewal for EE, due to the need for accompanying measures, the failure of which would compromise the implemented ESM	Medium
	Renovation potential	(+)	There is great potential for implementing measures on building installations and the utilization of renewable energy	High
		(+)	Better thermal conditions in the homes will be reached with the implementation of EE measures	High
		(+)	The renovation actions extend the life of buildings.	Medium
		(-)	Lack of technical capacity of local authorities to manage building renovation programs and implement investor supervision	Medium
		(-)	Low-skilled staff, short deadlines and low procurement prices lead to poor performance of the implementation of EE measures	Medium
	Monitoring and smart city platforms	(-)	Lack of regulatory penalties and fines for poor quality of the renovation processes, before and after their implementation	Medium
		(-)	Inefficient spending of the targeted social aid for heating – there is no control and monitoring of how it is spent.	Medium
		(-)	Smart metering is still not well-recognised	Medium
	Technical requirements	(+)	Introduction of requirements, higher than the minimum, regarding the basic renovation of the buildings when financing projects with a public resource.	Medium
	New energy-saving technologies	(-)	Still high prices of energy storage technologies	Medium
Environment	*Adaptation policies*	(+)	There is a defined Disaster and Accident Protection Policy	
	Adaptation policies	(-)	Limited knowledge of adapting buildings to climate change	High
	Sustainable energy resources/potential	(+)	High energy saving and RES potential	Medium
		(+)	The installation of systems for the production of electricity from renewable energy sources reduces the final energy consumption, and hence the CO_2 emissions at local level	Medium

Legal	*Level of compliance with the laws*	(+)	The number of ordinances for Low Energy efficiency was reduced and optimised	Medium
	Laws & regulations on permissions and licenses (e.g., for renewables installations, buildings, production sites etc.)	(+)	Changes have been made in the Law on Territorial Development, where the government finally accepted the abolition of the building permit and other procedures for the installation of photovoltaic on houses. This is a hugely important change for people, which would save a huge amount of administrative hassle, and that was the main barrier.	High
		(-)	The excess energy is still not purchased (the procedure is too complicated), which requires the installation of a battery	High
		(-)	No legislation and incentives for energy communities	High
	Legislative and regulatory framework (e.g., for energy, spatial planning, environment, regional development)	(+)	Adoption and implementation of the National Energy and Climate Plan and the Long-term Strategy for the Renovation of the Building Stock as the roadmap for 2030	High

6 Roadmap

6.1 Methodological approach

The building renovation roadmap resulted from the implementation of a methodological approach, which consisted of four different steps (Figure 43).

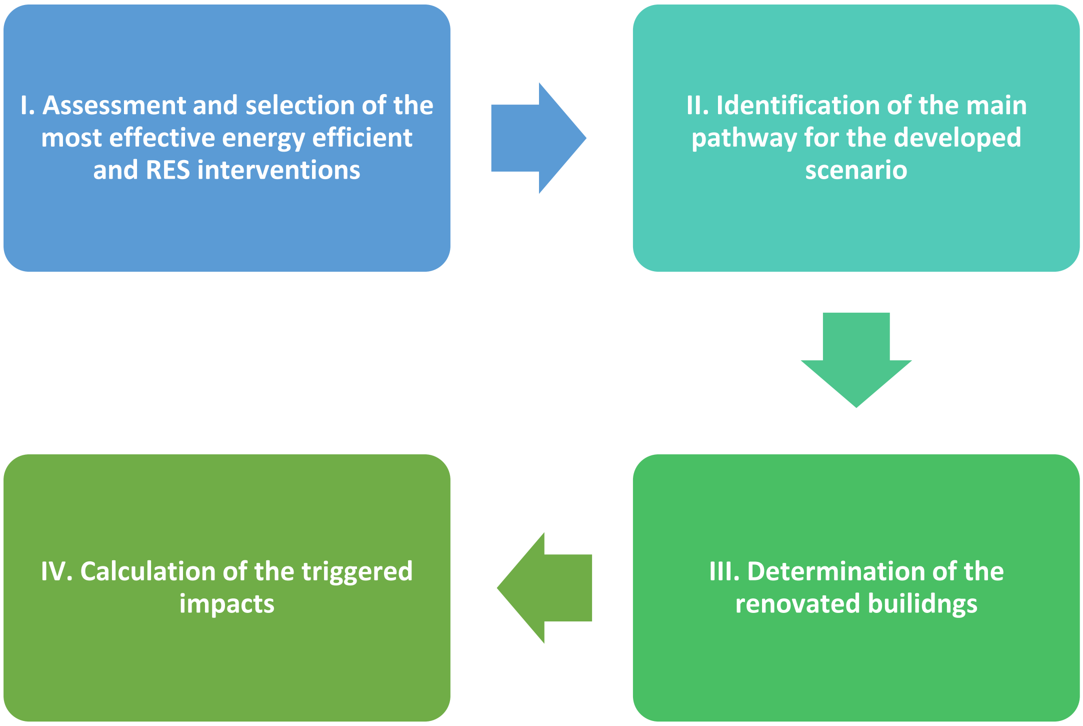

Figure 42. Applied methodological approach.

Firstly, the assessment and selection of the available energy-efficient and RES interventions occurred in Step I. Three different combinations of energy efficient and RES interventions were modelled to evaluate their performance and to select the most cost-effective one taking into consideration the cost-effectiveness ratio based on the delivered energy savings and CO_2 emission reduction. The main pathway for combating energy poverty through the renovation of the building stock was identified in Step II taking into account the selected energy efficient and RES interventions within the framework of Step I. Moreover, the number of renovated buildings was calculated for the formulated pathway in Step III, while the utilization of unitary metrics for the most effective energy-efficient and RES interventions led to the quantification of the triggered impacts in Step IV.

6.2 Step I: Assessment and selection of the most effective energy efficient and RES interventions

The vision of the Brezovo building renovation roadmap is based on renewed and decarbonized building stock by 2050, which provides a high quality of life in a healthy, safe, energy-efficient, modernized and high-tech living environment, based on a complex of linked factors, such as active participation of users for the efficient use of energy, management of energy production and consumption in the building and professional management of the building stock. The roadmaps should ensure a modern, up-to-date and cost-effective regulatory framework by introducing the "Energy Efficiency First" principle.

In order to achieve a high degree of energy efficiency and decarbonization of the existing housing stock, it is necessary: (1) to limit energy needs, by means of improving the energy characteristics of the external building elements and the systems for ensuring the microclimate; (2) more of the required energy to be produced from sources with low CO_2 emissions (renewable energy). Three different combinations of energy efficient and RES interventions were examined (Table 12).

Table 12. Examined combinations of energy efficient and RES interventions for SFB.

	O1	O2	O3
WALLS	Walls are insulated with a 50mm thick layer of mineral wool insulation with a heat conductivity rating of λ≤0.039 W/mK.	Walls are insulated with a 120mm thick layer of mineral wool insulation with a heat conductivity rating of λ≤0.039 W/mK.	Walls are insulated with a 120mm thick layer of mineral wool insulation with a heat conductivity rating of λ≤0.039 W/mK.
ROOF	Roof is insulated with a 100mm thick layer of rigid mineral wool insulation boards with a heat conductivity rating of λ≤0.039 W/mK.	Roof is insulated with a 150mm thick layer of rigid mineral wool insulation boards with a heat conductivity rating of λ≤0.039 W/mK.	Roof is insulated with a 150mm thick layer of rigid mineral wool insulation boards with a heat conductivity rating of λ≤0.039 W/mK.
BASEMENT	The building plinth is additionally insulated with a 100mm thick layer of XPS with a heat conductivity rating of λ≤0.036 W/mK, at least 50cm below grade level to ensure insulation layer extension below ground freezing layer.	Unheated basement ceiling is insulated with a 100mm thick layer of mineral wool insulation with a heat conductivity rating of λ≤0.03 W/mK. The building plinth is additionally insulated with a 100mm thick layer of XPS with a heat conductivity rating of λ≤0.039 W/mK, at least 100cm below grade level to ensure insulation layer extension below ground freezing layer.	Unheated basement ceiling is insulated with a 100mm thick layer of mineral wool insulation with a heat conductivity rating of λ≤0.041 W/mK. The building plinth is additionally insulated with a 100mm thick layer of XPS with a heat conductivity rating of λ≤0.036 W/mK, at least 50cm below grade level to ensure insulation layer extension below ground freezing layer.
DOORS	All old wooden staircase entrance doors are changed with insulated metal doors with a U value of 1.40 W/m²K	All old wooden staircase entrance doors are changed with insulated metal doors with a U value of 1.40 W/m²K	All old wooden staircase entrance doors are changed with insulated metal doors with a U value of 1.40 W/m²K
WINDOWS	All old wooden windows are changed with triple glazing windows in PVC frame with a combined U value of 1.1 W/m²K	All old wooden windows are changed with triple glazing windows in PVC frame with a combined U value of 1.1 W/m²K	All old wooden windows are changed with triple glazing windows in PVC frame with a combined U value of 1.1 W/m²K
TECHNICAL SYSTEMS	-	-	High-efficient individual A2A heatpumps A2W heatpump for DHW

The analysis led to the following results as presented in Table 13 in regard to the calculation of two different indicators for their comparative analysis.

Table 13. Results of the examined energy efficiency and RES interventions.

Cost effectiveness based on the final energy savings (€/kWh)	Single-family buildings
O1	3.14
O2	3.29
O3	3.55
Cost effectiveness based on the CO_2 emission reduction (€/kg CO_2)	**Single-family buildings**
O1	6.09
O2	6.24
O3	5.16

Assessment of additional measures for residential buildings

In addition to the energy renovation measures analysed in the renovation packages, namely building envelope measures, incl. replacement of window frames and installation of insulation on external walls, roofs and replacement of inefficient heating systems through the use of an alternative source, the roadmap also includes more ambitious measures such as the implementation of individual RES installations - photovoltaic installations for own consumption and solar thermal installations for domestic hot water.

Table 14. Assessment of measures for Residential buildings.

	Scope of the buildings	Final energy savings. MWh		Primary energy savings		CO2 emissions savings	
Measure		**Total**	**Per household**	**Total**	**Per household**	**Total**	**Per household**
		MWh		**MWh**		**tCO2/MWh**	
Deep renovation measures - external wall insulation. windows replacement. installation of heat pump for heating - 60% savings	100%	10593	3.954	13677.1	5.11	2202.2	0.82
Renewable energy generation PV roof installation -3 kWP with battery 10kWh	80%	8358.48	3.12	20896.2	7.80	4062.2	1.52
Renewable energy generation Solar collectors for DHW	20%	482.22	0.18	1205.55	0.45	234.4	0.09
Total savings		**19433.7**	**7.254**	**35778.8**	**13.36**	**6498.8**	**2.43**

To achieve the energy goals of the "Residential buildings" sector by 2050 deep renovation measures are assumed for 100% of occupied dwellings in the Municipality. For this purpose, available national resources and financial mechanisms, private investments and micro-lending can be used. It is planned RES technologies to be promoted among households, in order 80% of them to be introduced with PV roof installations and 20% with solar collectors for DHW. The expected savings from this approach contribute to total energy savings of 19433.7 MWh from the final energy. The expected primary energy savings are 13677.1 MWh and CO_2 emissions savings – 2202.2 tCO_2/MWh.

The PV installations will be for own consumption, with an installed power of the order of 2.5 to 3.5 kWp per household, in net metering mode with the electricity supplier, among 20% of households, will achieve renewable energy generation of 8358.5 MWh. The primary energy savings will be 20896.2 MWh and the CO_2 emissions savings – 4062.2 tCO_2/MWh.

By optimizing the domestic hot water supply with solar-thermal installations or individual air-water heat pumps for DHW to 20% of the dwellings, it will be possible to achieve savings of nearly 482 MWh from the final energy or 1205.55MWh primary energy.

The cumulative impact of all measures results in total final energy savings of 19433.7 MWh, primary energy savings of 35778.8 MWh, and CO_2 emissions savings of 6498.8 tCO_2/MWh.

The distribution of final energy savings in residential buildings by type of measure is presented in the figure below.

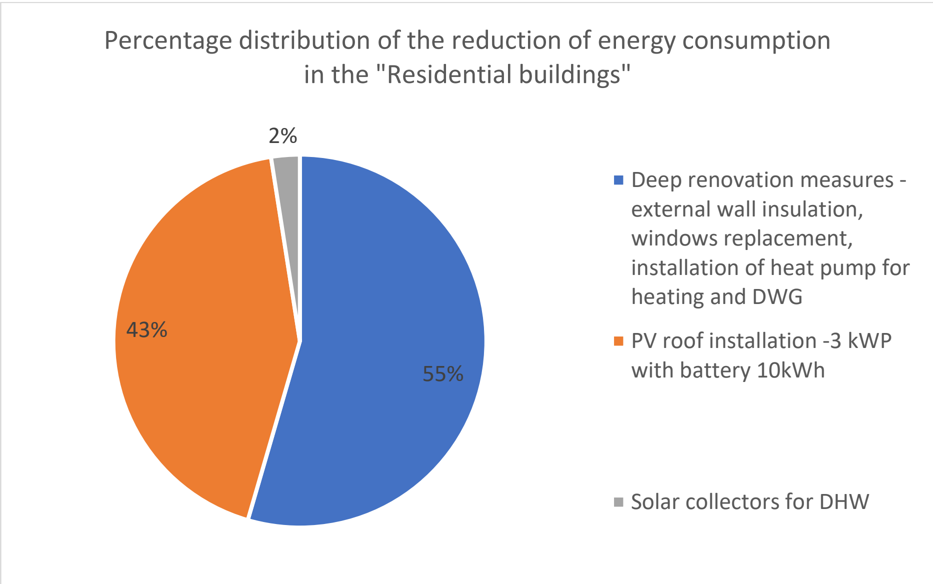

Figure 43. Percentage distribution of the reduction of energy consumption in the "Residential buildings".

6.3 Step II: Identification of the main pathway for the developed scenario

The determination of the goals for the renovation of the residential and social building stock is following the scenario with additional policies and measures used in the National Long-Term Strategy for Building Renovation Towards 2050 and the Integrated Energy and Climate Plan of the Republic of Bulgaria 2021 - 2030 which sets the goals of 27.89% savings in primary energy and 31.69% in final energy.

The main aim of the building renovation roadmap is to accelerate the deep renovation of residential single-family houses so as to ensure the effective alleviation of energy poverty. The combination of energy efficiency and RES interventions as outlined in the third option is an essential approach to facilitate the deep renovation of the buildings that are dwelled by energy-poor households.

Another important factor that will be taken into account is the heating source: a total of 2,249 out of 2,710 habitable dwellings are heated with solid fuel (wood and coal) - that's more than 82%.

The unitary results of the selected combination of energy-efficient and RES interventions are presented in Table 15.

Table 15. Estimated unitary results for the selected energy efficiency and RES interventions per building.

Selected energy efficiency and RES interventions	Single-family buildings
Final energy savings (MWh/year)	7.25
Primary energy savings (MWh/year)	13.36
CO_2 emission reduction (tCO_2/year)	2.43
Investment cost (€)	40729
Cost savings (€/year)	870

To achieve significant results in the renovation of single-family buildings, the Municipality needs to employ the following roadmap for implementing policies and introducing incentives for citizen participation in the process of renovation of single-family buildings.

<table>
<tr><th>2024</th><th>2025</th><th>2026</th><th>2027</th><th>2028</th><th>2029</th><th>2030</th><th>2040</th><th>2050</th></tr>
<tr><td>One stop shop development</td><td colspan="8">Continue operation and function of One stop shop for renovation</td></tr>
<tr><td colspan="2">RA visits</td><td colspan="5">Continue engaging, training and organisation of RA visits</td><td colspan="2"></td></tr>
<tr><td colspan="2">Adoption of methodology for identifying energy poor households</td><td colspan="5"></td><td colspan="2"></td></tr>
<tr><td colspan="7">Organisation of information campaigns, trainings and workshops for citizens, inviting experts and companies</td><td></td><td></td></tr>
<tr><td></td><td colspan="2">Implementation and monitoring of the Regulation on Energy performances of buildings</td><td colspan="4">Identifying interest-free self-financing loan instruments</td><td></td><td></td></tr>
<tr><td></td><td colspan="3">Encouraging owners to apply for funding under the program Development of the regions</td><td colspan="5">Identifying opportunities to promote energy renovation of single-family residential buildings</td></tr>
<tr><td colspan="9">Vulnerable households to be financed with a 100% grant for renovations (possible source: Social Climate Fund)</td></tr>
<tr><td>Information campaigns about the Programme for RES integration at homes</td><td colspan="2">Encouraging owners to apply for funding in Programme for RES integration at homes</td><td colspan="2">Encouraging owners to invest their own funds in RES and use the income/savings to partially cover the deductible</td><td colspan="4">Energy communities establishment</td></tr>
<tr><td colspan="3">Effective implementation of control and imposition of sanctions in the application Regulation for Energy performances of buildings</td><td colspan="5">Subsequent energy survey to verify the results of the implemented measures</td><td></td></tr>
<tr><td colspan="3">Communication campaign at local level</td><td colspan="6">Involving owners as active participants in decision-making regarding energy matters</td></tr>
<tr><td colspan="3"></td><td colspan="6">Consolidation and Long-term Monitoring</td></tr>
</table>

6.4 Step III: Determination of the renovated buildings totally

Under Directive (EU) 2018/844 of the European Parliament and the Council, amending Directive 2010/31/EU, a Long-term national strategy has been developed to support the renewal of the national building stock of residential and non-residential buildings until 2050 (Adopted by the Council of Ministers with Protocol No. 8 of 27.01.2021), in which the following are defined:

- indicative intermediate goals for 2030, 2040 and 2050;
- financial means to support the implementation of the strategy;
- effective mechanisms to promote investment in building renovation.

The national objectives for renovation of the residential and non-residential building stock, according to the Long-term national strategy, are given in Table 16.

Table 16. National objectives for renovation of the residential and non-residential building stock.

Indicator		2021-2030	2031-2040	2041-2050
Total energy savings	GWh/y	2 917	6 502	7 329
Residential buildings	GWh/y	2 477	5 694	6 294
Non-residential buildings	GWh/y	440	808	1 035
Renovated area	m2	22 203 509	49 570 668	55 823 015
Residential buildings	m2	19 026 656	43 735 175	48 343 297
Non-residential buildings	m2	3 176 852	5 835 493	7 479 718
Renovated area from the existing building stock for renovation at the moment	%	8%	18%	20%
Saving CO_2 emissions	tonne	1 306 435	2 891 610	3 274 453
Residential buildings	tonne	**1 065 184**	2 448 461	2 706 441
Non-residential buildings	tonne	241 251	443 149	568 012

The present Roadmap aims to renovate around 20% of the occupied residential buildings until 2050, considering that the average percentage of energy-poor households in Brezovo is about 20%.

Information about the number of the new and cumulative renovated buildings is provided in Tables 17 (for the different examined periods) and 18 (cumulatively) correspondingly, including the respective trajectory and timeline.

The simultaneous implementation of the foreseen energy efficiency and RES interventions is recommended. The insulation of the building envelope should be prioritised and the sizing of the heat pump should be performed taking into account the reduced heating and cooling demand. Finally, the installation of the solar thermal system and roof PV installations are foreseen interventions for the coverage of the heating and cooling needs.

Table 17. Number of newly renovated buildings for the examined periods.

Roadmap I	**2025-2030**	**2031-2035**	**2036-2040**	**2041-2045**	**2046-2050**
SFB	106	106	106	106	106

Table 18. Number of cumulatively renovated buildings for the examined periods.

Roadmap I	**2025-2030**	**2031-2035**	**2036-2040**	**2041-2045**	**2046-2050**
SFB	106	212	318	424	530

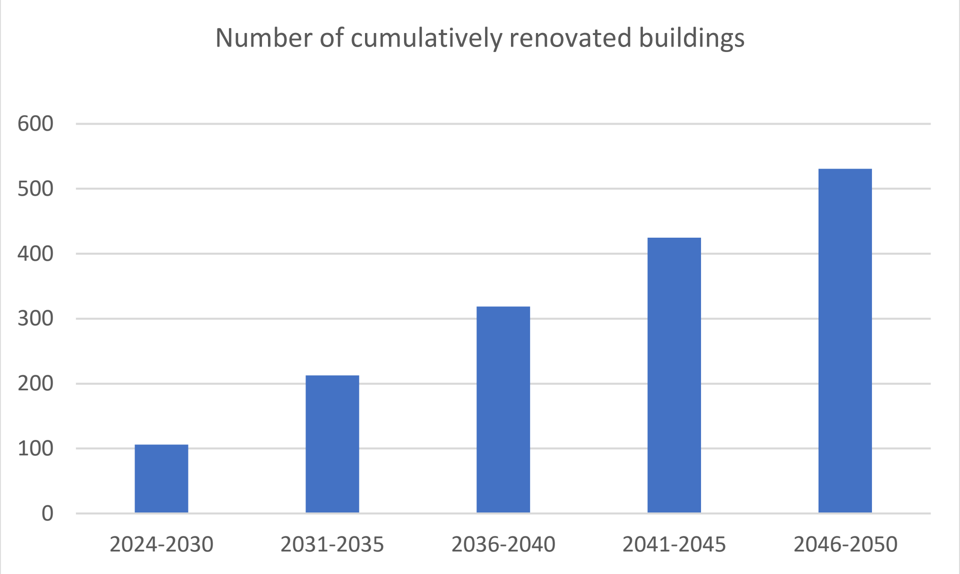

Figure 44. Number of cumulatively renovated buildings for the examined periods.

The estimation of the triggered impacts by the energy efficiency and RES interventions was implemented with the utilization of unitary metrics as resulted from the modelling activity, which was carried out for each examined measure within the framework of Step I.

6.5 Step V: Calculation of the triggered impacts for all renovated buildings

The expected cumulative final energy savings, primary energy savings and CO_2 emission reduction (calculated over the examined periods) are presented in Tables 19-23 respectively. The calculation of the delivered impacts was performed using the unitary metrics in Table 19 and the cumulative number of renovated buildings.

Table 19. Resulted cumulative final energy savings (GWh) for the examined periods.

Roadmap I	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
SFB	0.77	1.54	2.31	3.07	3.84

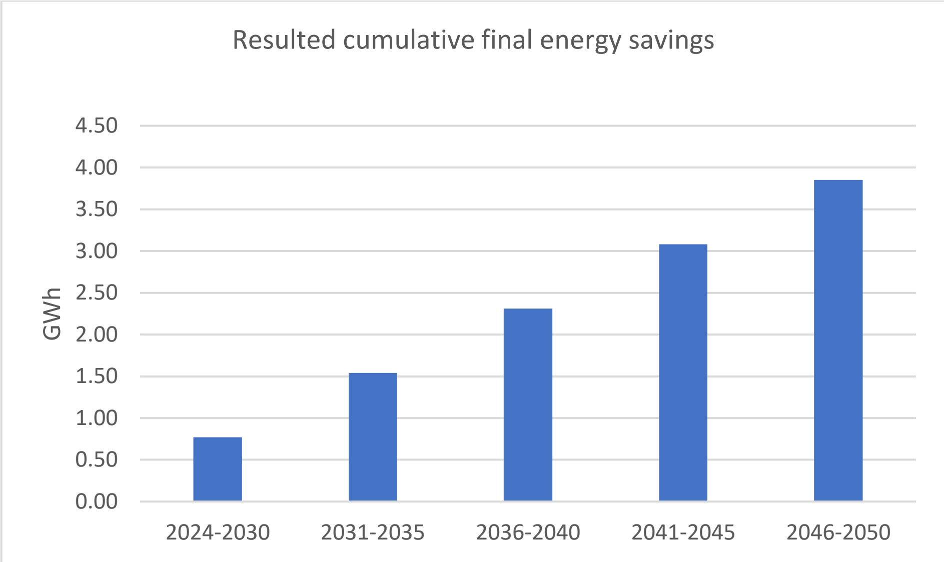

Figure 45. Resulted cumulative final energy savings (GWh) for the examined periods.

Table 20. Resulted cumulative primary energy savings (GWh) for the examined periods.

Roadmap I	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
SFB	1.42	2.83	4.25	5.66	7.08

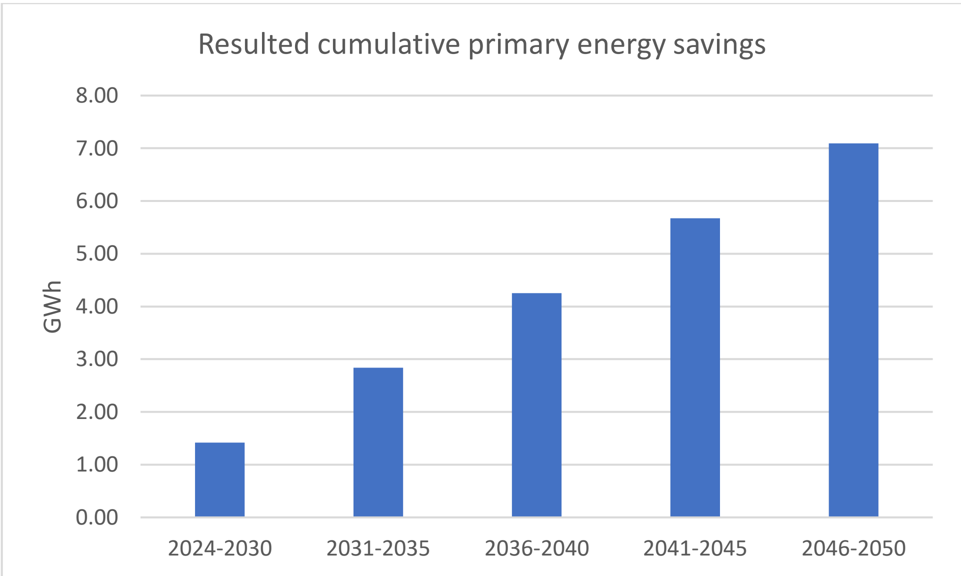

Figure 46. Resulted cumulative primary energy savings for the examined periods.

Table 21. Resulted cumulative CO2 reduction (ktn CO_2) for the examined periods.

Roadmap I	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
SFB	0.26	0.52	0.77	1.03	1.29

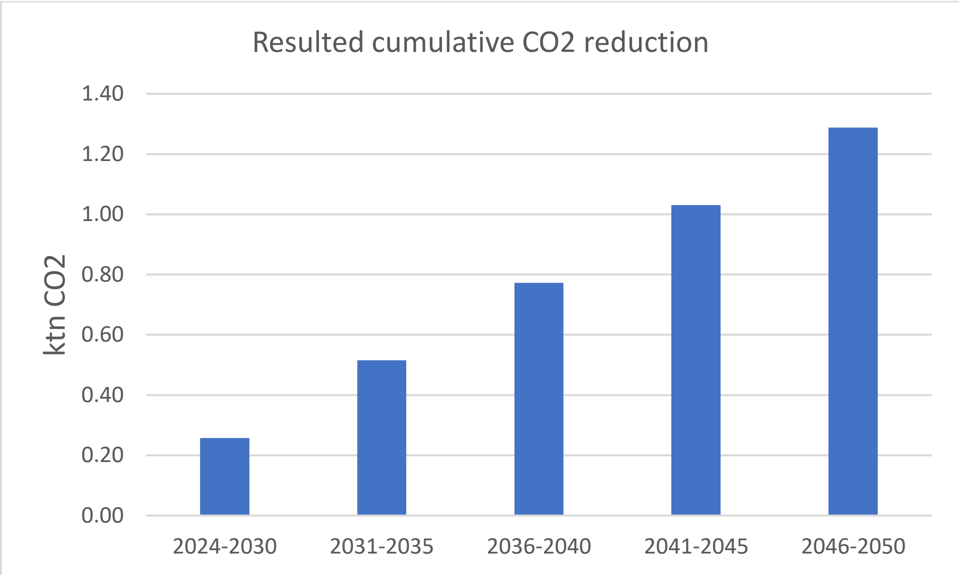

Figure 47. Resulted cumulative CO_2 reduction for the examined periods.

Two main factors determine the effect on employment: investments in energy efficiency create jobs in the industry that produces the relevant products and services, and the energy savings achieved reduce in the long term the consumption of energy products. In turn, the reduction in consumption affects the added value produced, and the change in added value leads to an effect on employment in the respective sector.

The expected employment impacts were calculated (Table 22) using the respective results of the COMBI project, i.e. about 15.5 person-years/million EUR invested in building renovations. It should be noted that the calculation was performed based on the number of newly renovated buildings.

Table 22. Resulted employment impacts (person-years) for the examined periods.

Roadmap I	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
SFB	66.9	66.9	66.9	66.9	66.9

Finally, the expected cumulative multiple benefits were calculated (Table 23) assuming that are equal to 0.0212 €/kWh (calculated on first-year savings) for the cumulative number of renovated buildings in each examined period. The multiple benefits were estimated by making use of the monetisation results of COMBI online tool (COMBI project, 2018). More specifically, the following benefits have been considered: Avoided asthma morbidity due to indoor dampness; Avoided electricity generation from combustibles-based power plants; Avoided direct GHG emissions; Avoided premature mortality due to inadequate heating and cooling; Avoided Morbidity due to indoor air pollution; Avoided yearly deaths due to reduced ozone exposure; Avoided yearly deaths due to PM2.5 exposure; Avoided life expectancy loss due to PM2.5. For more details refer to Section 6.2.4 of D2.1 “State-of-the-art review and assessment report”.

Table 23. Resulted cumulative multiple benefits (million €) for the examined periods.

Roadmap I	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
SFB	0.016	0.033	0.049	0.065	0.081

7 Policies and measures

The specified renovation targets will be achieved with the design and implementation of 5 policies and measures. It should be mentioned that the described policies and measures are in full alignment with the provisions of the NECP.

The main measures for lowering the final energy consumption in residential buildings are related to:

- Energy renovation of buildings - external construction measures, incl. replacement of window frames and installation of insulation on external walls, roofs, floor structures;
- Replacement of the heating method – switching to a highly efficient form of heating through the use of an alternative source;
- Encouraging the implementation of individual RES installations - photovoltaic installations for own consumption; solar thermal installations for heating DHW; air-water heat pumps for heating water for DHW;
- Conducting campaigns to increase the population's knowledge of energy-efficient measures and smart energy consumption;
- Encouraging behaviour change;
- Replacement of old household electrical appliances with new ones with energy class C and better.

Information about the existing (or expected) policies and measures is provided in the following tables.

Name of policy or measure	M1: Program for the financing of single measures for energy from renewable sources (RES) in single-family buildings and multi-family buildings.
Short description	The program provides for the financing of two types of measures for renewable energy in households: - construction of solar systems for DHW: the maximum amount of free financing per individual household is expected to be 100% of the value of the system, but not more than BGN 1,960.83; - construction of photovoltaic systems up to 10 kW: the maximum amount of free financing for an individual household is expected to be up to 70% of the value of the system, but not more than 15,000 bgn. Energy-poor households can apply for free financing up to 100% of the value of the system, but not more than bgn 15,000.
Quantified objective	Introduction of RES in residential buildings
Type of policy or measure	Economic measure
Planned budget and funding sources	Households can install photovoltaic installations with a power exceeding 10 KWp and a value of BGN 15,000, but grant funding is limited to BGN 15,000.
Entities responsible for implementing the policy	Ministry of Energy
Number of affected households	106 households dwelling in single-family houses (SFH)

Name of policy or measure	M1: Program for the financing of single measures for energy from renewable sources (RES) in single-family buildings and multi-family buildings.
Expected impact in relation to the specified targets	Final energy savings: 0,77 GWh Primary energy savings: 1,42 GWh GHG emissions savings: 0,26 ktn CO_2
Status of implementation	Expected
Date of entry into force	2024
Implementation period	2024-2027

Name of policy or measure	M2: Program "Regions Development” URBAN DEVELOPMENT" Energy efficiency in residential buildings
Short description	Measures for energy efficiency and sustainable renovation of multi-family and single-family residential and public buildings, incl. student and student dormitories • Awareness raising campaigns and all types of EE measures in buildings, incl. structural (and seismic) strengthening; • Heating and air conditioning systems; • Integrated on-site renewable energy installations; • Equipment for charging electric cars; • Digitization of buildings; • Green infrastructure, etc. The activities will be carried out in accordance with the long-term strategy for the rehabilitation of the building stock in the Republic of Bulgaria with a horizon until 2050. The activities must lead to the achievement of at least class "B" energy consumption of the building and at least a 30% reduction of direct and indirect greenhouse gas emissions compared to prior emissions
Quantified objective	Renovation of the residential buildings
Type of policy or measure	Economic measure
Planned budget and funding sources	These measures will only be financed through a combination of an own contribution or a financial instrument within a single operation. In the case of financing with a combination of BPF and financial instruments, the permissible amount of BPF will be determined by the entity implementing the financial instrument. For energy-poor households and student dormitories, 100% BFP will be allowed. For all others, the minimum required own contribution is 5% of eligible costs.
Entities responsible for implementing the policy	Ministry of Regional Development and Public Works
Number of affected households	106 households dwelling in single-family houses (SFH)
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M1

Name of policy or measure	M2: Program "Regions Development” URBAN DEVELOPMENT" Energy efficiency in residential buildings
Status of implementation	Expecting
Date of entry into force	2024
Implementation period	2024-2027

Name of policy or measure	M3: Information and awareness-raising programs
Short description	Conducting local information campaigns to raise public awareness of the potential financial, health, economic, social and environmental benefits, to promote and attract interest in deep renovation and RES implementation and to support application to the financial schemes.
Quantified objective	Renovation of the residential buildings
Type of policy or measure	Capacity building measure
Planned budget and funding sources	Public and private funds
Entities responsible for implementing the policy	Municipality of Brezovo
Number of affected households	530
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M1
Status of implementation	Existing
Date of entry into force	2025
Implementation period	2025-2050

Name of policy or measure	M4: Establishing OSS
Short description	**A one-stop service model (including providing personalized advice to building owners and investors) for advice on the whole renovation process**
Quantified objective	Renovation of the residential buildings
Type of policy or measure	Supportive measure
Planned budget and funding sources	Public and private funds
Entities responsible for implementing the policy	Municipality of Brezovo
Number of affected households	530 households dwelling in single-family houses (SFH)
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M1
Status of implementation	Initiated
Date of entry into force	2025
Implementation period	2025-2050

Name of policy or measure	M5: Promoting energy audits in households
Short description	**M5** will support financially the conduction of energy audits. More specifically, a pilot program will be launched for the residential buildings covering the implementation cost to increase their awareness and to promote their further conduction according to the provisions of the EED. Furthermore, the derived recommendations can be supported through the provision of financial aid.
Quantified objective	Awareness-raising for issues related to the building renovation. Carrying out surveys and implementation of measures for energy efficiency of single-family and multi-family residential buildings on the territory of the Municipality of Brezovo.
Type of policy or measure	Awareness-raising measure
Planned budget and funding sources	Grant funding - National program for energy efficiency in multi-family residential buildings
Entities responsible for implementing the policy	Ministry of Environment and Energy
Number of affected households	106 households dwelling in single-family houses (SFH)
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M1
Status of implementation	Planned
Date of entry into force	2025
Implementation period	2025-2027

8 Investment needs

The investment needs that are required for the implementation of the building renovation roadmap, are presented in Tables 24 (for the different examined periods) and 25 (cumulatively) both for the case of the new and cumulative ones.

Table 24. Required new investments (million €) for the examined periods.

Roadmap I	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
SFB	4.32	4.32	4.32	4.32	4.32

Table 25. Required cumulative investments (million €) for the examined periods.

Roadmap I	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
SFB	4.32	8.63	12.95	17.27	21.59

It should be noted that the planned investments will be carried out with 100% public funding.

9 Renovations triggered by REVERTER project

REVERTER is expected to contribute to the renovation of single-family buildings by the end and five years after the completion of the project (2025-2030) through the establishment and operation of the physical and digital one-stop shops, visits to homes of energy-poor households by REVERTER Ambassadors who will inform them about energy renovation issues and awareness-raising and training activities to reinforce the existing level of knowledge of the energy-poor households. According to the initial estimates described in Section 3 “Impact calculation table” of D1.4 “Extract of the project data from the LIFE KPI webtool”, approximately 980 households in Municipality of Brezovo will be reached through information campaigns, home visits and social engagement events.

Of these households, it is estimated that 500 will be approached by visits, 200 will be reached by social engagement events and around 280 will be approached through media campaigns. It is expected that more than 100 energy-poor households living in single-family and multi-family houses (around 10% of the households approached) will adopt deep renovation measures.

The contribution of REVERTER project in renovating single-family houses of energy-poor households, including post-project period, is summarised in Table 26.

Table 26. Contribution of REVERTER project to the implementation of the specific roadmap for the renovation of single-family buildings in the period 2025-2030.

Impacts	Energy-poor households – Single-family buildings
Number of renovated buildings	48
Resulted cumulative final energy savings (GWh)	0.35
Resulted cumulative primary energy savings (GWh)	0.64
Resulted cumulative CO_2 reduction (ktn CO_2)	0.12
Resulted employment impacts (person-years)	30.3
Resulted cumulative multiple benefits (million €)	0.007
Required new investments (million €)	1.95

10 Monitoring and evaluation framework

A holistic monitoring and evaluation framework will be established to monitor and assess the implementation of the building renovation roadmap and the realization of the planned investments.

The proposed monitoring and evaluation mechanism consists of seven different sub-mechanisms, which are related either directly or indirectly (coordination, monitoring, measurement, data collection, control and verification, reporting and evaluation mechanisms) as depicted in Figure 50.

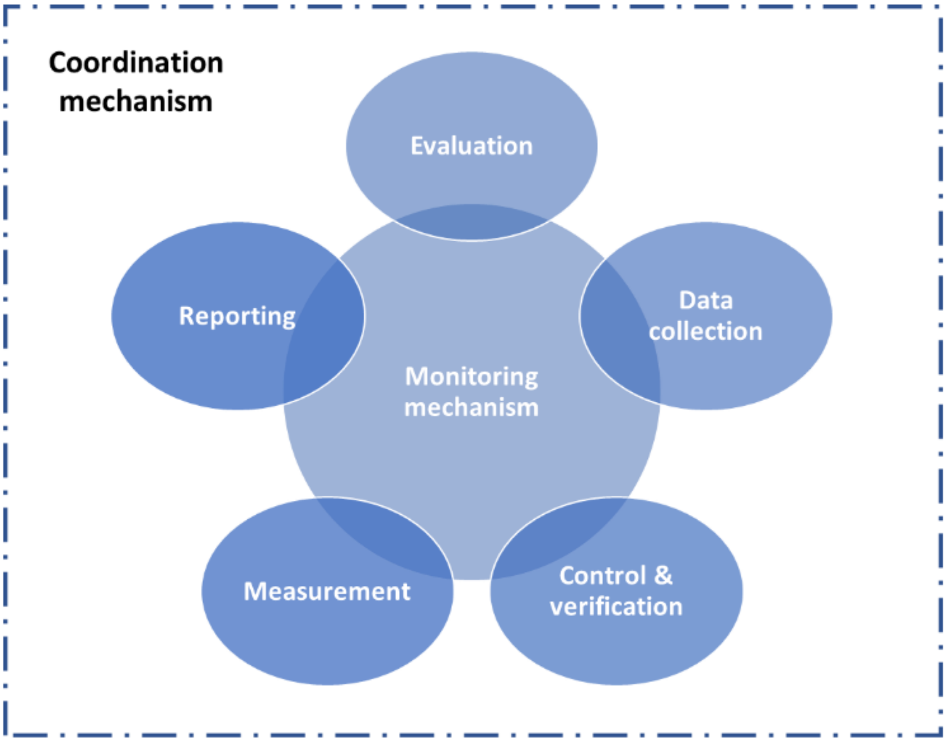

Figure 48. Overview of the sub-mechanisms within the established monitoring and evaluation framework.

The municipality of Brezovo is the responsible authority for the proposed monitoring and evaluation mechanism.

The role of the coordination sub-mechanism is considered the most important one, as it will facilitate the efficient cooperation and implementation of the remaining six sub-mechanisms, ensure the coherence of the monitoring and evaluation mechanism with the energy efficiency and RES investments and create the appropriate conditions of commitment and trust among the involved authorities and bodies.

The coordination sub-mechanism should be developed to facilitate the vertical and horizontal coordination of the planned activities. Vertical coordination ensures effective communication and administration among the different governmental levels, namely national, regional and local levels for designing and implementing energy efficiency policies and/or concrete measures. Horizontal coordination enables the effective communication and administration of the different energy efficiency measures, and schemes or programmes at the same level.

The monitoring sub-mechanism aims at the continuous monitoring of the implemented energy efficiency and RES implementation activities and the delivered impacts s to initiate the appropriate measures in the case that the progress is not assessed as satisfactory and according to the roadmap. The monitoring sub-mechanism should be based on the combination of top-down and bottom-up monitoring. The top-down monitoring will be carried out with the monitoring of specific statistical data at national and sectoral levels about the evolution both of the final energy consumption and the energy poverty. Simultaneously, the framework for bottom-up monitoring should be established for collecting information on the number of renovated buildings. It should be pinpointed that the introduction of bottom-up monitoring affects the implementation of the measurement, control, verification and data collection procedures.

The development of the measurement sub-mechanism should be implemented taking into consideration the provisions of Annex V of the Directive 2023/1791/EE. Specifically, the calculation of the achieved energy savings could be conducted through the utilization of five different calculation methods (deemed savings, metered savings, scaled savings, surveyed savings and savings of people affected by energy poverty, vulnerable customers, people in low-income households and, where applicable, people living in social housing based on engineering estimates using standardized occupancy and thermal comfort conditions or parameters.

The data collection sub-mechanism should consist of six different steps. Initially, the energy efficiency and RES investment should be selected for monitoring and assessment in Step 1. Then, the various types of data, which should be collected, have to be identified within the context of Step 2. The selection of the required data must be done along with the measurement method either top-down or bottom-up, which has been developed for each energy efficiency and RES investment separately.

After the identification of the data, the available data sources should be mapped in Step 3, while the responsible body and the respective procedure for the collection of the identified data must be specified. It is crucial to define with clarity what type of data should be collected by each involved body, how these data will be analysed and by whom. Step 4 foresees the collection of the required data from the identified data sources.

Moreover, a specialized procedure should be implemented to control and validate the collected data following specific criteria, such as their accuracy, robustness and coherence within the control and verification sub-mechanism in Step 5. Indicative methods in order to validate the compliance with these criteria include the evaluation of the closeness between the estimated results and the true values, the comparison of the obtained results with the respective ones over time and from other spatial domains and the comparison of the estimated results with the corresponding ones from different sources or methods. Finally, a combination of verification and control techniques (plausibility check, desktop checks, on-site checks on a specific sample and extrapolation to the total investments) to the collected data should be conducted in Step 6 to ensure the quality of the collected data as displayed in Figure 51.

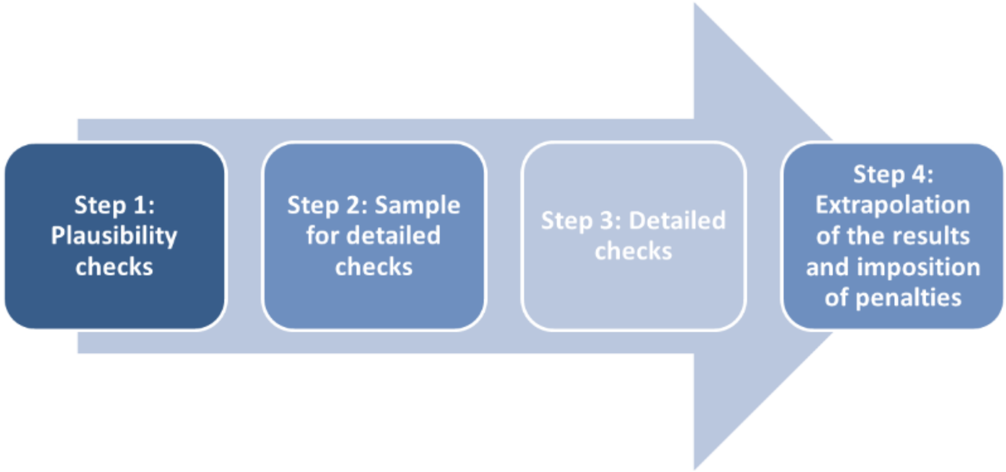

Figure 49. Steps for the conduction of the required control and verification activities.

The reporting of the implemented energy efficiency and RES investments should be performed on an annual basis within the framework of the reporting sub-mechanism. The actual budget and the quantified impacts should be reported for each energy efficiency and RES investments separately. The calculation of the delivered energy savings will be performed in accordance with the selected measurement protocol. Moreover, additional quantitative information about the implementation of energy efficiency and RES investments should also be provided. It should be noted that the quantitative information must be linked with the developed bottom-up equations within the bottom-up monitoring. It is obvious that the required data will be collected by the implementation both of the foreseen top-down and bottom-up monitoring procedures.

Finally, all the implemented energy efficiency and RES investments should be evaluated within the framework of the assessment sub-mechanism through the conduction of cost-effectiveness and cost-benefit analyses. The analysis aims to assess the effectiveness of the implemented investments to decide either their continuation, or their improvement or their replacement with new more effective ones so as to achieve the specified renovation targets.

A template for the collection of the required data including the establishment of the appropriate data collection procedures will be prepared. Furthermore, the potential deviations for all the monitored indicators will be estimated taking into consideration the expected performance in the examined year according to the provisions of the building renovation roadmap compared to the actual ones.

The assessment of the implemented policies and measures can be performed at least using the following indicators:

- Investment cost/Final energy savings (million €/GWh)
- Investment cost/Primary energy savings (million €/GWh)
- Investment cost/CO_2 emission reduction (million €/ktn CO_2)
- Public funds/Final energy savings (million €/GWh)
- Public funds/Primary energy savings (million €/GWh)
- Public funds/CO_2 emission reduction (million €/ktn CO_2)
- Private funds/Final energy savings (million €/GWh)

- Private funds/Primary energy savings (million €/GWh)
- Private funds/CO_2 emission reduction (million €/ktn CO_2)

Last but not least, the potential adjustment of the building renovation roadmap should be initiated in the case of deviations from the planned renovation rate and the foreseen investments. A threshold should be specified for potential deviations (such as indicatively 10% deviation) to activate the adjustment of the building renovation roadmap taking into account the concluded outcomes from the assessment of the already implemented policies and measures and identifying an updated pathway for the attainment of the renovation targets.