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 IV: Roadmap I - Tenants in Athens Urban Area

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Executive summary

The REVERTER roadmaps aim to combat energy poverty by deeply renovating dwellings occupied by vulnerable households. The roadmaps were developed considering the conclusions and policy recommendations that resulted from analysing 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. At the same time, they intend to cover a sufficiently cohesive group of cases that will allow for a larger-scale rollout and replication of the proposed actions to effectively analyse and tackle 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 "Tenants in Athens Urban Area" is to help alleviate energy poverty in tenant dwellings (both single-family buildings and apartments in multi-family buildings) in the Athens Urban Area through the energy renovation of the building stock.

The Roadmap provides a pathway to be followed by local, regional and national authorities to upgrade a total of around 51,400 rented dwellings, more specifically 44,700 apartments and 6,700 single-family homes, by 2050. The abovementioned figures were calculated taking into account that in the Athens Urban Area (i) all residential buildings, which have been constructed before 2005, should be renovated starting with the worst-performing ones (for details refer to Section 4), (ii) 15% of the households are affected by the phenomenon of energy poverty (for details refer to Section 2), and (iii) 21% of energy-poor households rent their residences. To estimate the renovation costs three different renovation schemes were modelled and analysed. The installation of an aerothermal heat pump has the best performance on the examined indicators. Nevertheless, the combination of interventions in the building envelope with heat pump and solar thermal systems has also an acceptable performance and constitutes a meaningful option for the case of deep renovations.

Focusing specifically on renovations triggered by REVERTER (i.e. till the end of the project and 5 years beyond project-end) through the establishment and operation of the physical and digital one-stop shops, visits to homes of energy-poor households by REVERTER Ambassadors and the awareness-raising and training activities, it is estimated that 61 rented dwellings (apartments and single-family houses) will be retrofitted. The overall impacts of the project are summarised in Table ES1, while the allocation of the total investments to public and private investments triggered by the project is presented in Table ES2.

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

Impacts	Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	Energy-poor households Tenants – Single-family houses (SFH)	*Total*
Number of newly renovated buildings	**53**	**8**	**61**
Resulted cumulative final energy savings (GWh)	0.55	0.24	0.78
Resulted cumulative primary energy savings (GWh)	0.71	0.29	1.00
Resulted cumulative CO_2 reduction (ktn CO_2)	0.15	0.07	0.21
Resulted employment impacts (person-years)	22.71	5.62	28.33
Resulted cumulative multiple benefits (million €)	0.02	0.01	0.04
Required new investments (million €)	**1.47**	**0.36**	**1.83**

Table ES2. Allocation of the total investments to public and private investments triggered by the REVERTER project (million €) in the period 2025-2030.

Period	Roadmap	Energy poor households	Share	Public funds	Private (own) funds	Total
2025-2030	**Energy-poor households Tenants – Multi-family houses-Apartments (MFB)**	**Category I**	20%	0.15	0.15	0.29
		Category II	30%	0.33	0.11	0.44
		Category III	50%	0.66	0.07	0.73
		Total	**100%**	**1.14**	**0.33**	**1.47**
	Energy-poor households Tenants – Single-family houses (SFH)	**Category I**	20%	0.04	0.04	0.07
		Category II	30%	0.08	0.03	0.11
		Category III	50%	0.16	0.02	0.18
		Total	**100%**	**0.28**	**0.08**	**0.36**

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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, which is observed in the case of tenants dwelling in the Athens Urban Area (pilot area). The confrontation of energy poverty will be achieved through the energy renovation of the building stock. The compilation of the building renovation roadmap will accelerate the renovation of the building stock both in multi-family buildings (apartments) and single-family buildings, which are used by tenants as residences.

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

The National Energy and Climate Plan (NECP), which was submitted at the end of 2019, defines the policy framework for the energy upgrade of the building stock. The adopted NECP intends to renovate 60 thousand buildings annually in the period 2021-2030, while a holistic combination of policy measures is foreseen for the attainment of the specified target. The revised NECP, which was prepared in October 2023, increased the ambition regarding the renovation target. More specifically, the annual share of residential buildings, which will be energy upgraded, will increase to 1.4 % in 2030 (corresponding to approximately 79 thousand buildings annually) from 0.8 % today (corresponding to approximately 47 thousand buildings annually) leading ultimately to energy renovation of 19% of residential buildings. The renovation rate is expected to increase to 1.7 % in 2050, contributing to the energy upgrade of 43% of residential buildings.

It should be noted that it is foreseen also a considerable penetration of heat pumps. The number of residential buildings with installed heat pumps will increase from 8% in 2021 to 17% in 2030. The respective penetration amounts to 91% in 2050.

The Ministry of Environment and Energy (YPEN) is responsible for undertaking the legislative obligations for the energy performance of buildings. The national building code, known as the 'Regulation on the Energy Performance of Buildings' (KENAK), underwent amendments in July 2017, and the corresponding Technical Guidelines received approval in November 2017. KENAK establishes minimum requirements, specifically maximum U-values for building elements, as well as criteria for energy losses and gains across the entire building envelope. Additionally, it outlines minimum efficiency standards for heating, cooling, and hot water production systems, derived from a cost-optimal study. Consequently, existing buildings or units undergoing major renovations can achieve optimal energy savings with minimal cost impact.

The definition of major renovation is established in Law 4122/2013, and subsequently amended by Law 4409/2016. A renovation is categorized as deep when the total cost related to renovating the building envelope or technical building system exceeds 25% of the building's value, excluding the value of the land on which the building is situated. For existing buildings undergoing deep renovation, the minimum energy performance requirements are met when the building: (a) satisfies all minimum criteria for existing buildings, and (b) the calculated annual total primary energy consumption is less than or equal to that of the reference building, while the building is

classified at least as Class “B”. Exceptions are permissible only if a technical report demonstrates that meeting these standards is not technically, functionally, and economically feasible.

The definition of Nearly Zero-Energy Buildings (NZEB) for existing buildings is outlined in Law 4122/2013, with its application elucidated in the national NZEB study issued in December 2018. The national plan, released in August 2018, aimed at increasing the number of nearly zero-energy buildings, stipulates that an existing building qualifies as a nearly zero-energy building if it falls under at least energy class B+. However, a decision on the minimum share of Renewable Energy Sources (RES) and its contribution to primary energy consumption is still pending.

Details on the energy performance of a building and recommendations for enhancing its efficiency are incorporated into the Energy Performance Certificate (EPC), which remains valid for 10 years. The EPC becomes mandatory upon the completion of the construction of a new building, after a comprehensive renovation, during the sale of a building, or when leasing to a new tenant. Under Law 4342/2015, effective from November 9, 2015, all new rentals are required to include the unique protocol number of the EPC in the electronic platform of the General Secretariat of Information Systems of the Ministry of Finance.

Furthermore, a crucial emphasis is given to the optimal integration of Renewable Energy Sources (RES) technologies for heating and cooling within the building sector. This emphasis is particularly significant as the mandate stipulates that all new buildings are to achieve nearly zero-energy status from 2021 onward. In a significant development, the Hellenic Parliament passed a comprehensive law in March 2023, encompassing various facets of renewable energy installations. This law includes provisions such as setting the maximum capacity for rooftop photovoltaic systems at 10 kW for households and 100 kW for businesses, an increase from the previous limit of 3 MW. The rationale provided by the government is the limitation of grid space.

The alleviation of energy poverty has been specified as an essential objective within the framework of the final NECP, which was submitted at the end of 2019. A quantitative target has been set for reducing energy poverty at least by 50% and 75% in 2025 and 2030 respectively in comparison to 2016, while the foreseen level in 2030 should be below the EU average in 2030. It should be noted that the same targets have been retained also in the draft revised NECP, which was submitted in October 2023. Moreover, targeted policy measures should be designed and implemented to tackle effectively the phenomenon of energy poverty, while emphasis should be given to the improvement of comfort conditions and the avoidance of the triggered health problems. Finally, the compilation of the Action Plan for the Confrontation of Energy Poverty was foreseen also in order to specialize the required measures.

The Action Plan for the Confrontation of Energy Poverty was prepared in September 2021 specializing the policy measures to ensure the fulfilment of the specified targets within the NECP. Moreover, the definition of energy-poor households was determined. Specifically, a household is characterized as energy-poor in the case that both of the following conditions are simultaneously fulfilled:

- Condition I: The total final energy consumption of the household is lower than 80% of the minimum final energy consumption, which is required theoretically for covering the thermal needs.
- Condition II: The total normalized income of the household, based on the number of the household’s persons according to the equivalence scale of OECD is lower

than 60 % of the median income of all the households in Greece.

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

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.

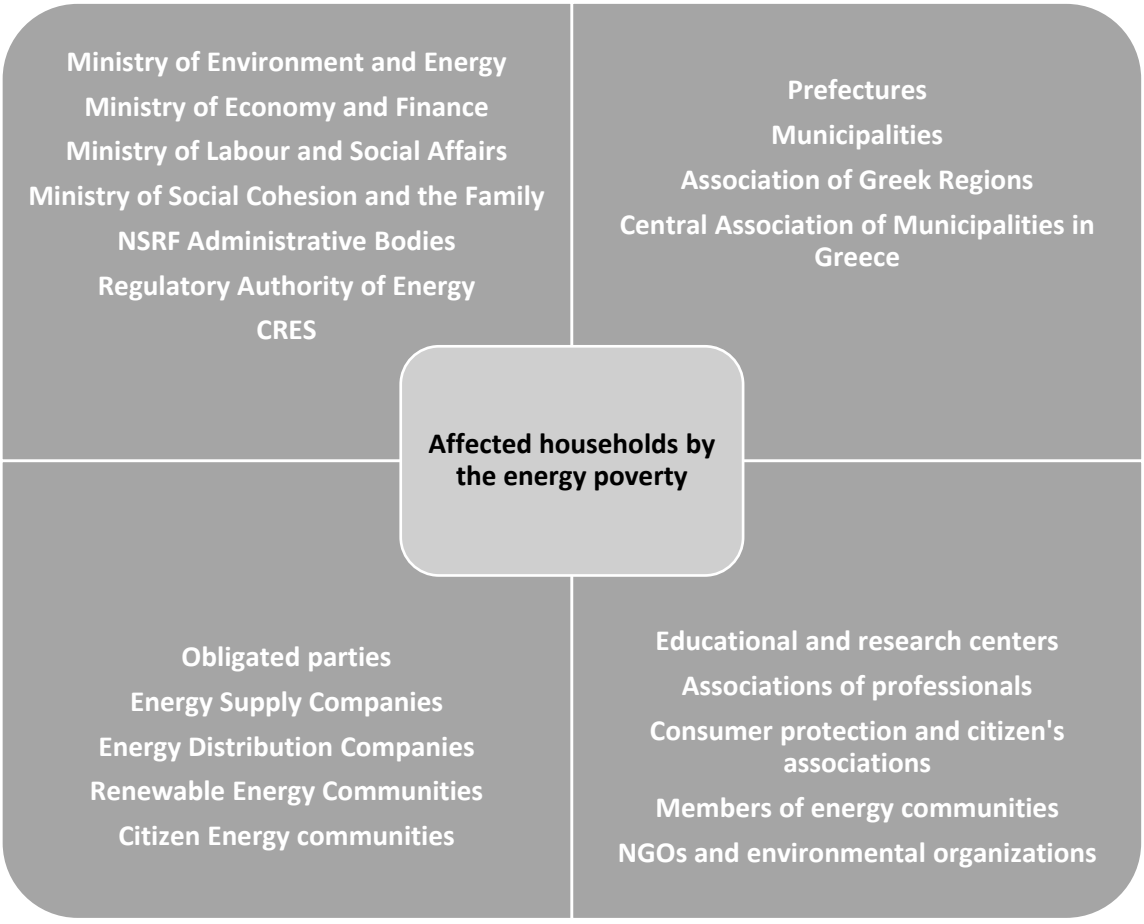

Figure 1. Overview of the involved stakeholders in the preparation of the building renovation roadmap.

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 by CRES under the auspices of the Ministry of Environment and Energy.
- 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 in the pilot of the Athens Urban Area regarding the current situation of energy poverty was carried out within the framework of Deliverable 3.2. It was based on data from Eurostat's EU SILC and HBS surveys, which were retrieved by the Hellenic Statistical Authority. The EU SILC and HBS survey microdata (at the household level) were provided for the years 2017-2021. From the dataset, the observations selected were those that referred to region EL30 (variable DB040) and degree of urbanization 1 (variable DB100 - cities/densely populated area).

As regards the EUSILC indicators, according to Figure 2, the share of the population living in a dwelling with a leaking roof, damp walls/floors/foundation within the Greek pilot area is lower than the national share (by 1.3%), as also has been the case since 2017, without significant differences over the years.

The share of the population not being able to keep their home adequately warm is slightly lower than the national level (by 0.8%) (Figure 3). Similar conclusions are drawn for the share of the population having arrears on utility bills, which is also lower than the respective national share (by 5.1%), and follows the same trend since 2017, with both the rates of the pilot-area level and the national level decreasing over time (Figure 4).

The differences between the shares of the pilot area and the national level do not follow a consistent pattern, yet both the EP rates of the pilot area and the national level are decreasing over time.

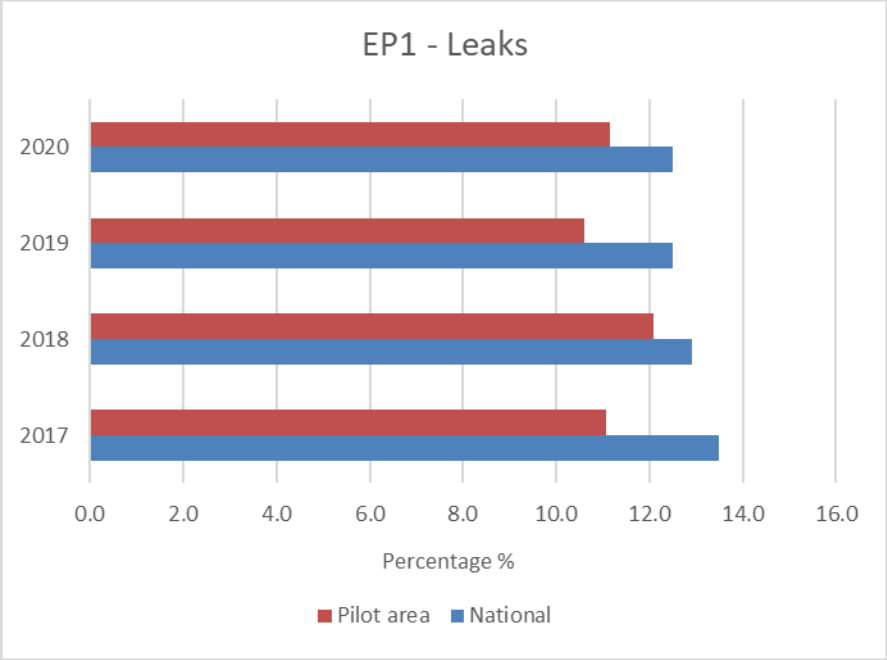

Figure 2. Share of the total population living in a dwelling with leaks.

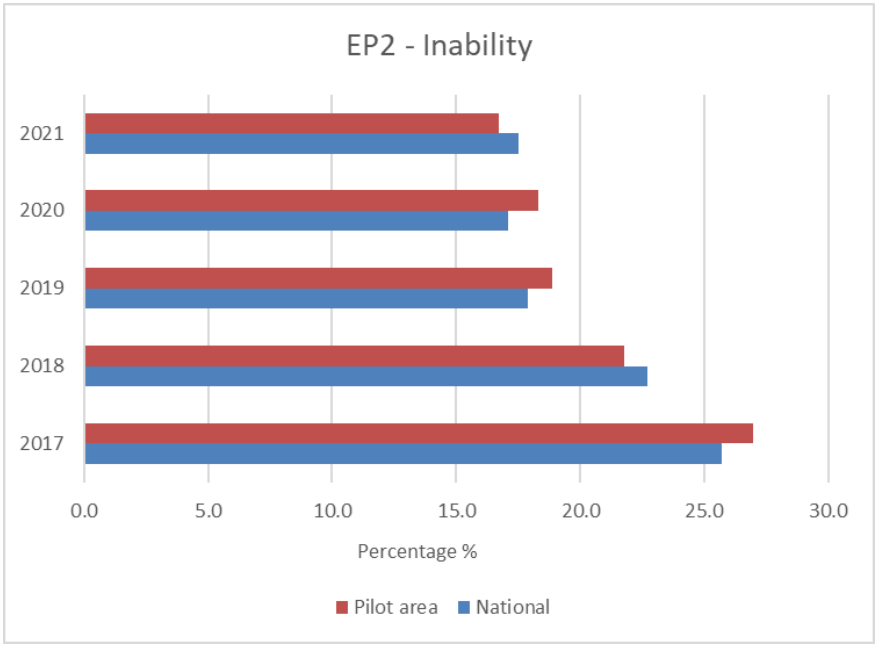

Figure 3. Share of the population not able to keep their home adequately warm.

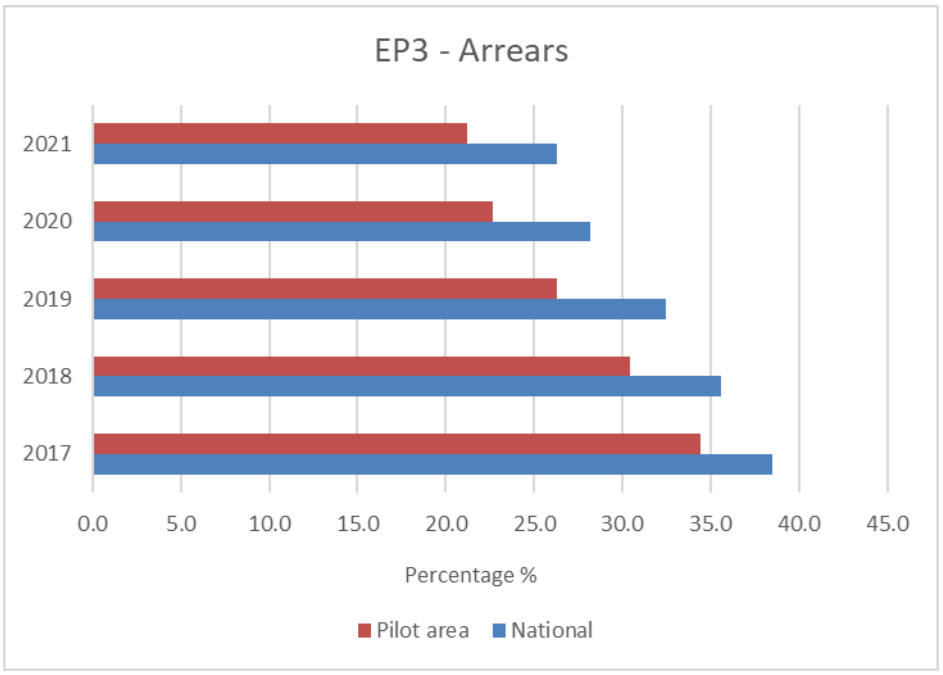

Figure 4. Share of the population having arrears on utility bills.

The rest EP indicators (i.e., EP4 to EP12) were examined only at the level of the pilot area, as not being official indicators. According to Figure 5, the share of the population with arrears on utility bills only once has been constantly decreasing since 2017 (a decrease of 42% was marked between 2017 and 2021). The same happens for the share of the population with arrears on their bills twice or more, with a reduction of 37% within the same years (Figure 6).

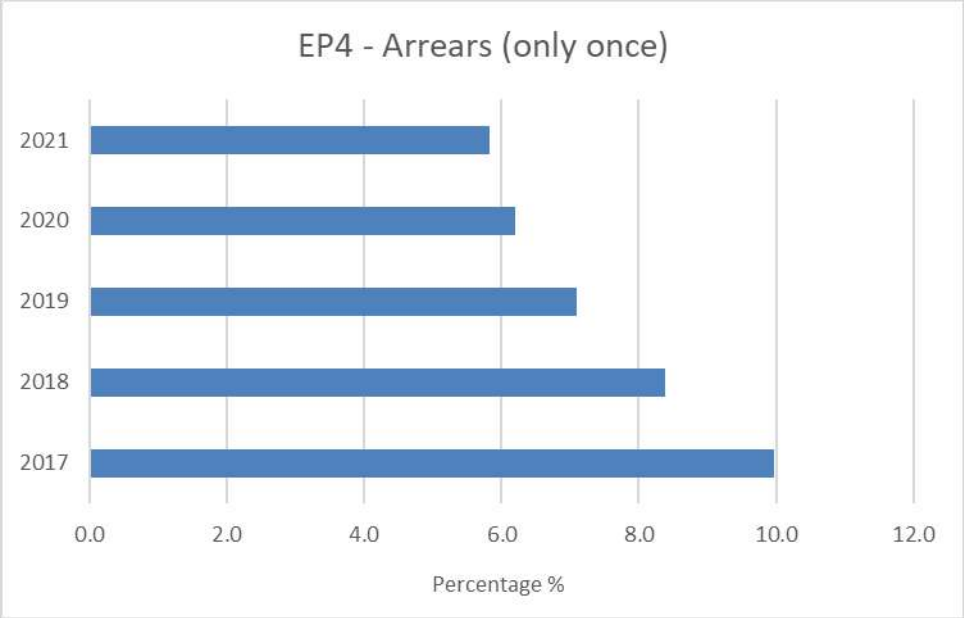

Figure 5. Share of the population having arrears on utility bills only once in the past 12 months.

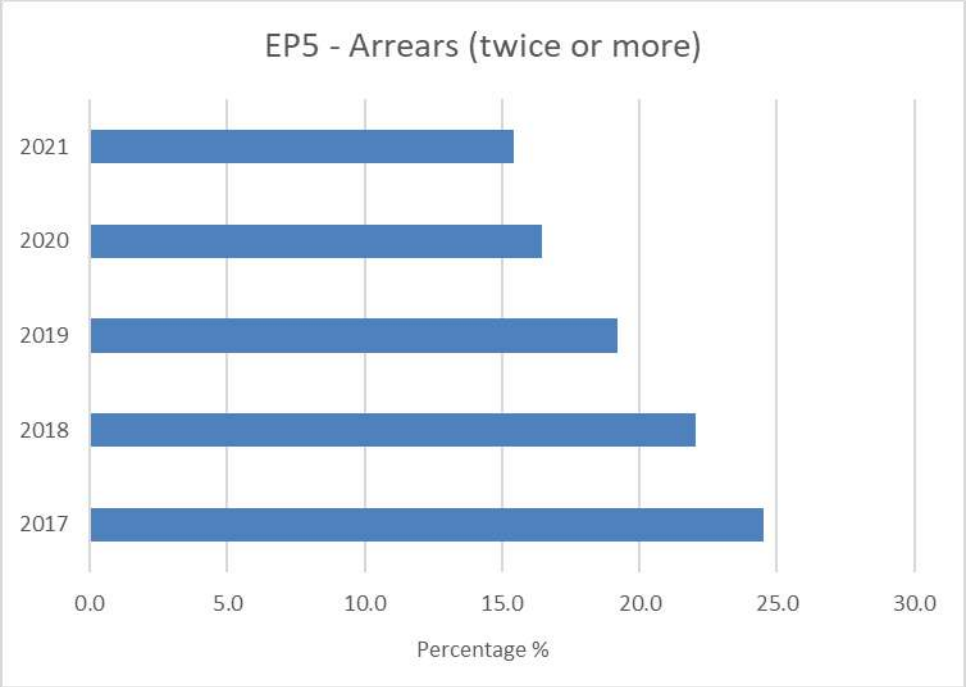

Figure 6. Share of the population having arrears on utility bills twice or more in the past 12 months.

The relative improvement in terms of EP issues is also apparent in the results of the Weighted Composite Indices. According to Figure 7, the share of the population not experiencing EP issues increased from 50.3% in 2017 to 63.3% in 2020, whereas the share of those experiencing severe EP issues (i.e., the WCI1 equals 1) dropped by just 0.5%. Similar conclusions are reached for the other two indices (WCI2 and WCI3), with the share of population without EP issues marking an increase over the last four years (Figure 8 and Figure 9, respectively).

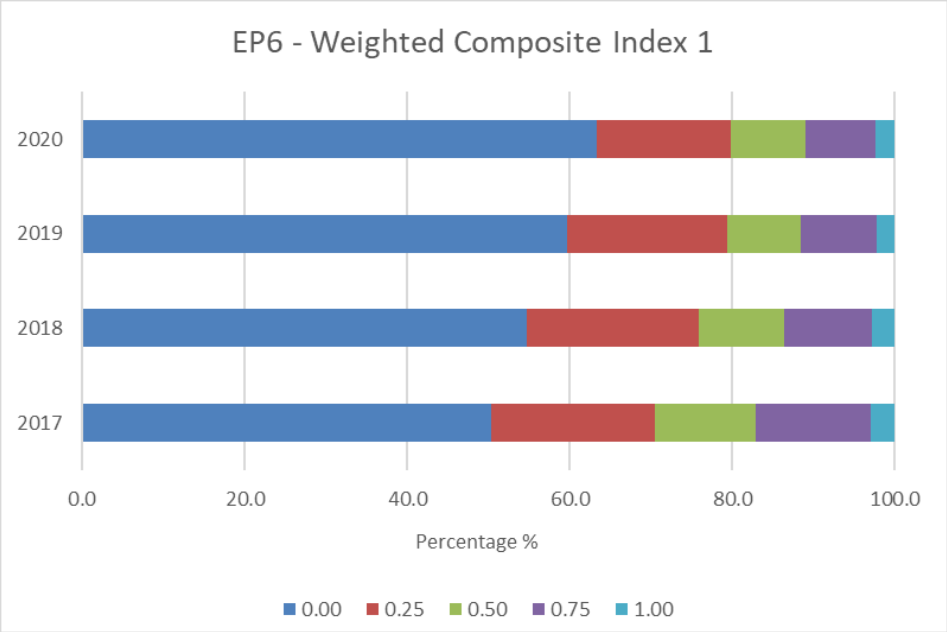

Figure 7. Share of population at EP according to WCI1.

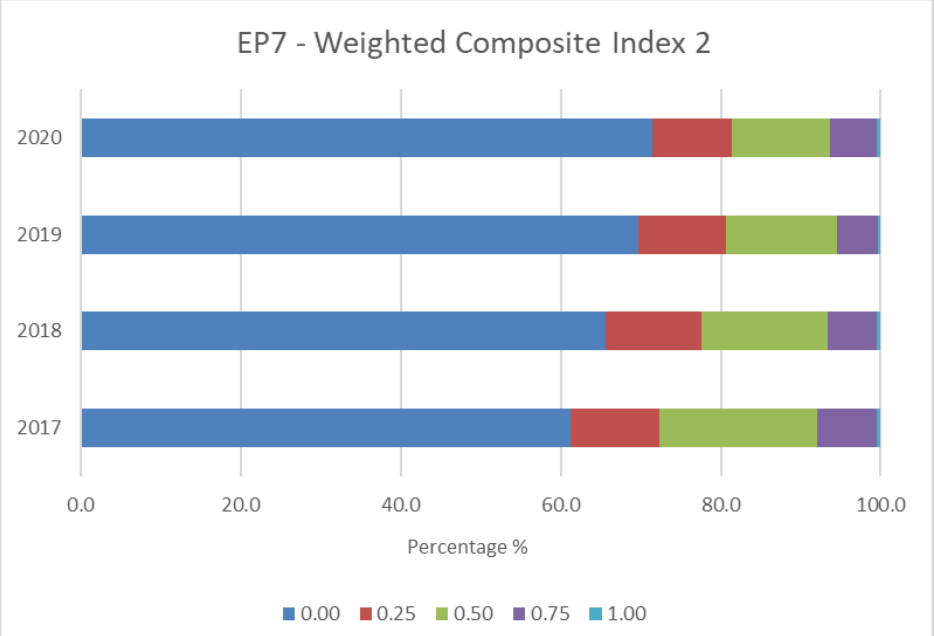

Figure 8. Share of population at EP according to WCI2.

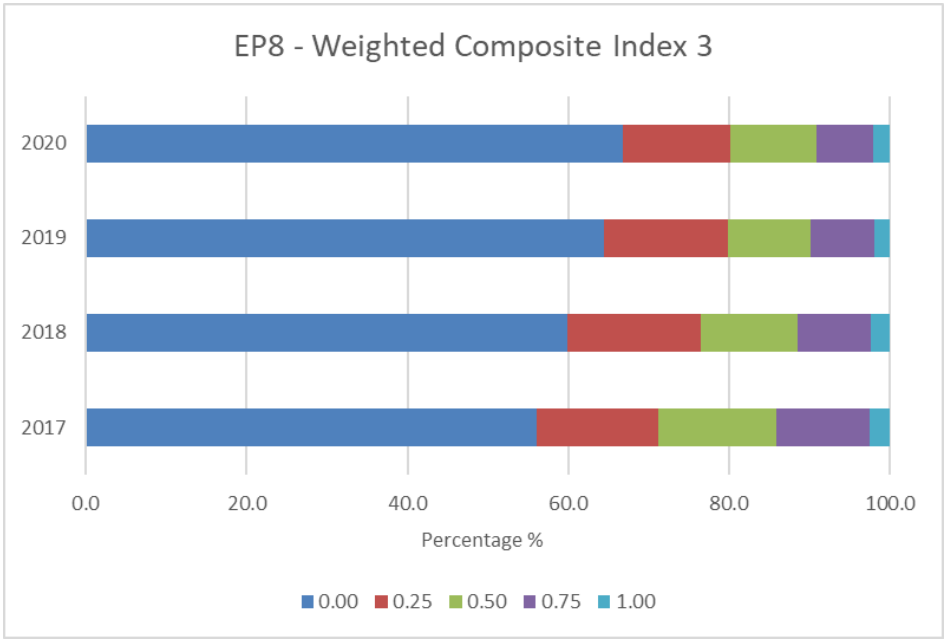

Figure 9. Share of the population at EP according to WCI3.

The Simple Composite Indices (SCI) follow a pattern similar to the Weighted Composite Indices analysed above, reflecting an overall improvement in EP issues. In all SCIs (Figure 10, Figure 11 and Figure 12), the share of the population not experiencing EP issues is increasing, while the rest classes of the population experiencing more important EP problems do not present significant changes over time. For example, SCI1 presents an increase from 50.3% to 63.3% between 2017 and 2020 for class 0 (population not experiencing EP issues), with the rest classes remaining almost stable over the years.

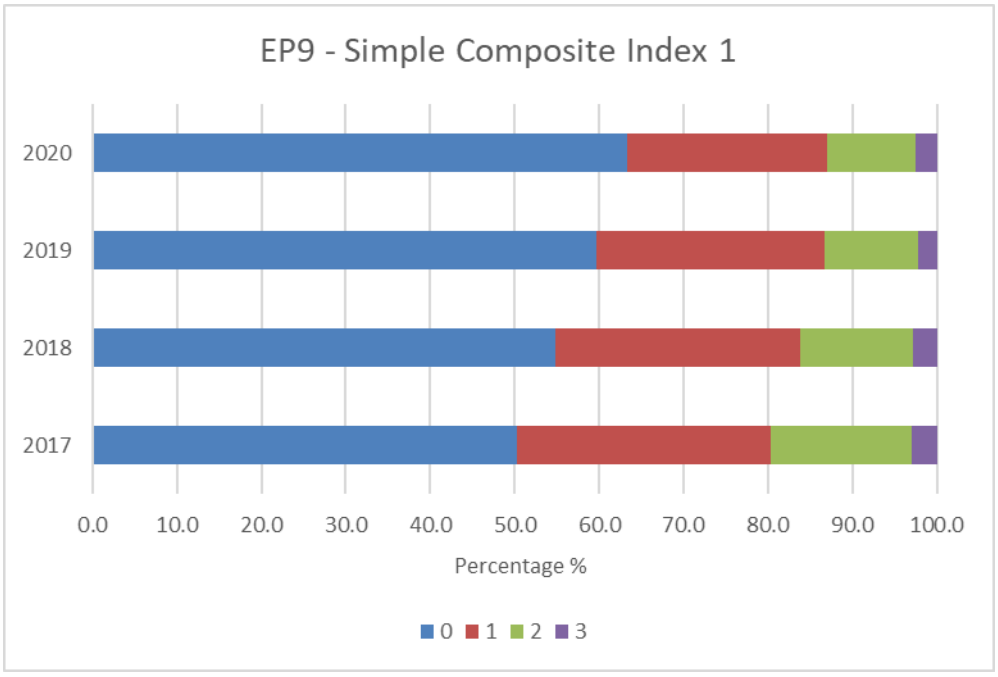

Figure 10. Share of population at EP according to SCI1.

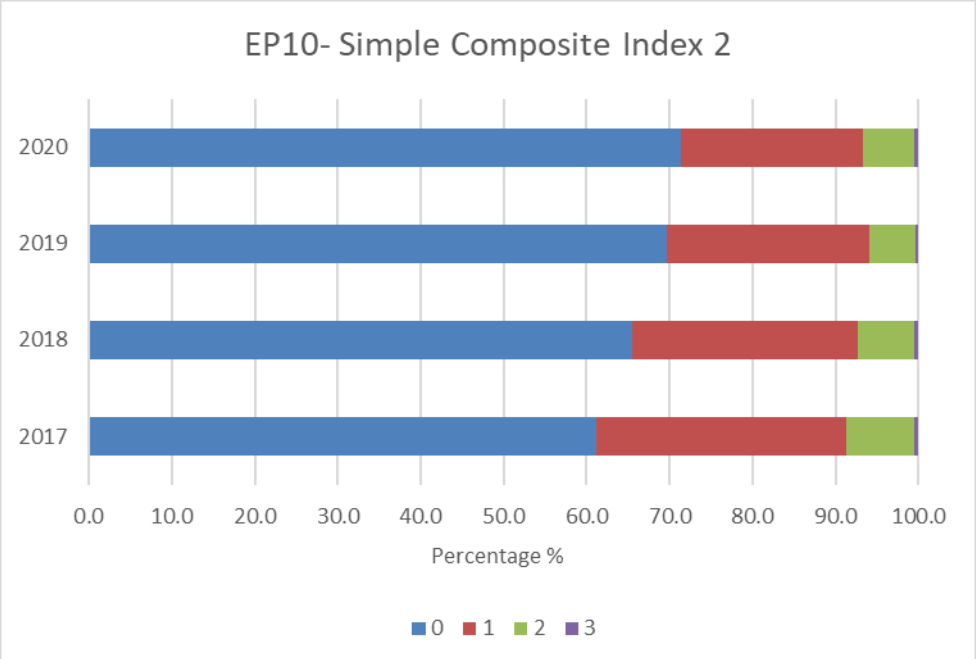

Figure 11. Share of population at EP according to SCI2.

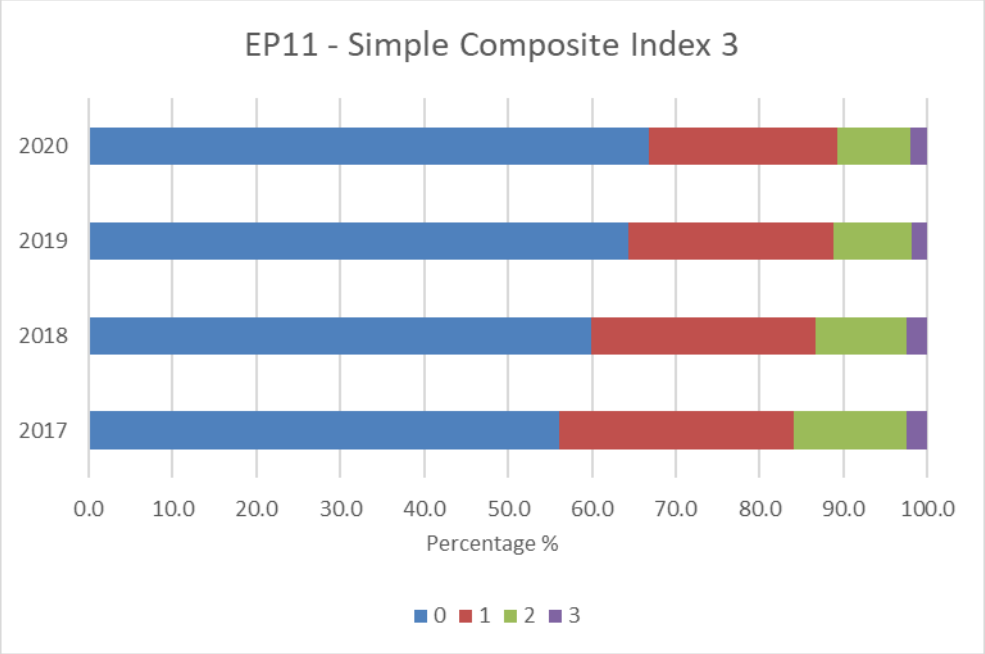

Figure 12. Share of the population at EP according to SCI3.

Finally, the percentage of the population experiencing any type of EP, i.e., arrears on utility bills, inability to keep their house adequately warm, or leaks/damp walls, has been constantly decreasing since 2017 (Figure 13). More precisely, a reduction of 26% was marked between 2017 and 2020. This kind of indicator presents high rates, as practically combines all single EP indicators.

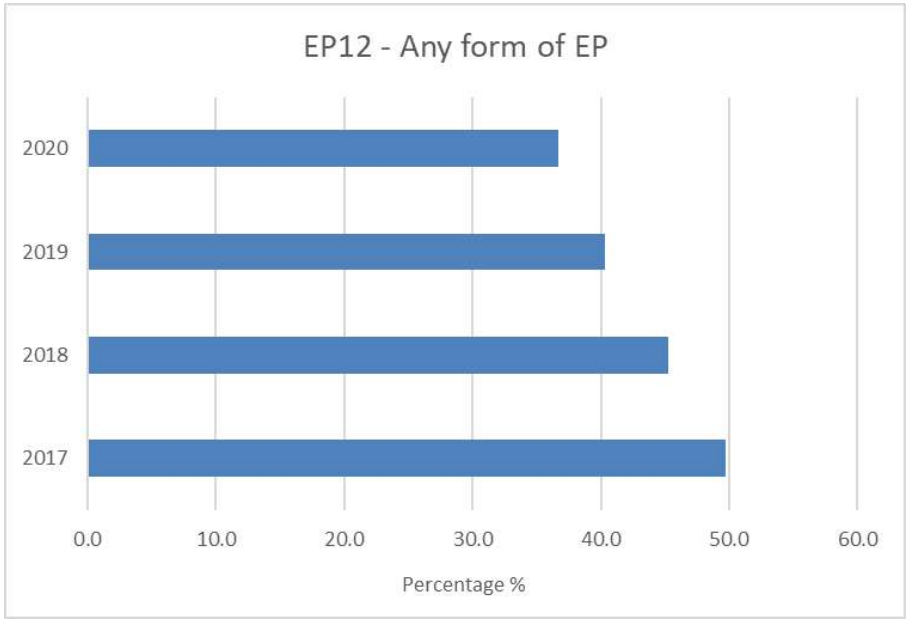

Figure 13. Share of the population at EP according to EP12.

Figure 14 shows that households experiencing great difficulty in making ends meet face also higher EP issues, with differences in EP rates of up to 21% compared to average rates. On the other hand, households that can easily make ends meet present quite lower EP rates, of up to 29% versus average rates.

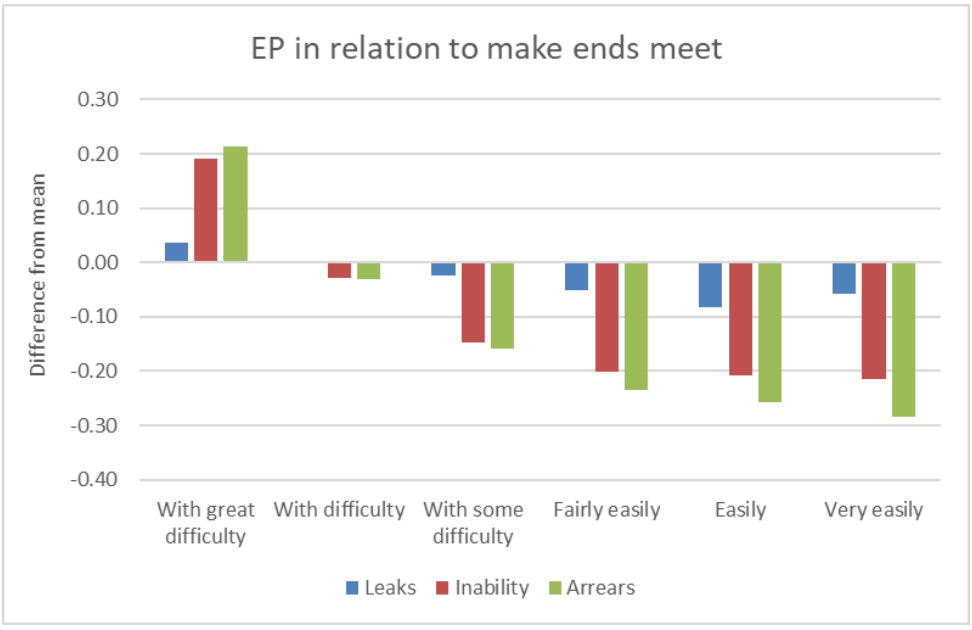

Figure 14. Leaks, inability to keep house warm and arrears on utility bills in relation to the level of difficulty in making ends meet.

Similar trends are detected when examining the complementary EP indicators. More specifically, the highest EP rates compared to the average are shown, in the case of those with great difficulty in making ends meet (Figure 15).

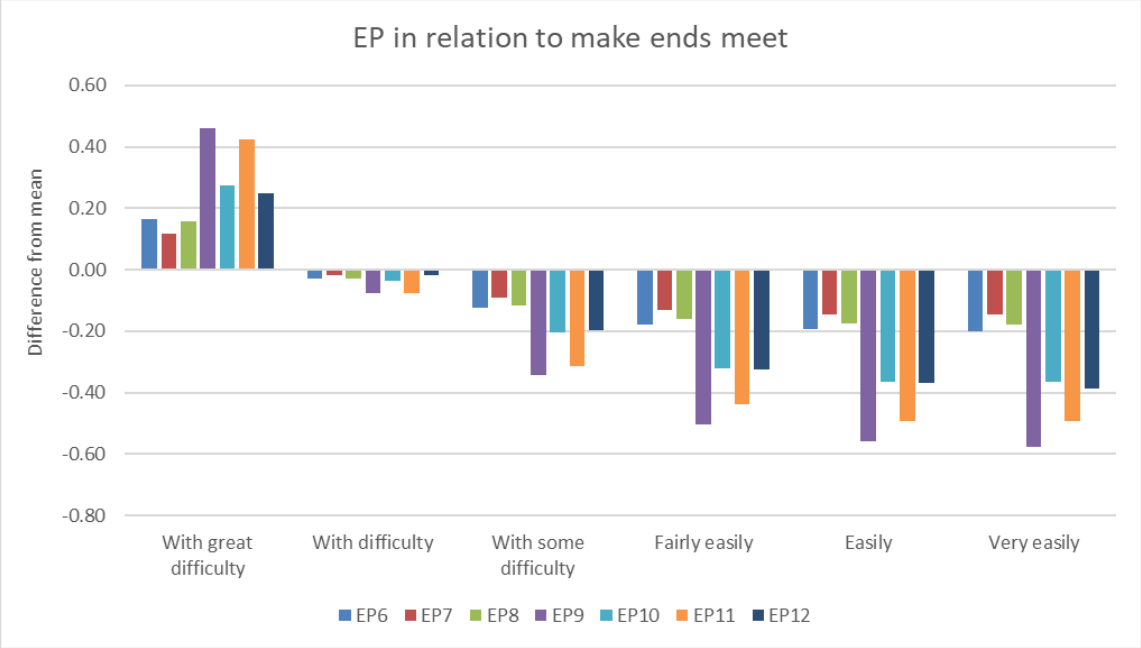

Figure 15. Complementary EP indicators in relation to the level of difficulty in making ends meet.

The expenditure indicators, which were calculated based on the HBS data, are presented in Figure 16. Considering the 2M index, the estimated levels of EP are very low (3-5%), which is largely attributed to the fact that the index does not count as energy-poor households that under-consume energy, a situation quite common in Greece during the last decade, due to shrinking incomes and high energy prices. With the M/2 index, energy poverty levels were calculated between 11% and 16% in the period 2017-2021. Nevertheless, this index shows also significant weaknesses as it may classify as EP, households whose energy costs are low because they live in homes with high energy efficiency, but it ignores households with high energy expenditures, though necessary to ensure adequate internal thermal conditions in the dwellings.
With the national index (NEPI), the levels of energy poverty were estimated at levels of 9-11% in the reference period. It is worth mentioning that the structure of the NEPI incorporates key dimensions of the EP problem, namely, the discrepancy between consumed and required energy to ensure adequate internal thermal conditions in homes as well as households' income. However, a key point of criticism for the NEPI is the ambiguity in defining the minimum required energy consumption that is used in developing the condition (i) of the adopted definition. In addition, the identification of energy-poor households requires a complex calculation process particularly the calculation of the minimum required energy consumption of the residence, which depends on its characteristics, the level of thermal insulation, the climatic conditions, etc.

Aiming to overcome these problems, two additional energy poverty indicators were formulated in the context of this analysis, namely the modified NEPI index, and the modified LIHC index. The estimated energy poverty levels for the Greek pilot based on the two new energy poverty indicators, are also shown in Figure 16, and were found to range from 9-11% with the modified NEPI index and between 22-26% with the modified LIHC.

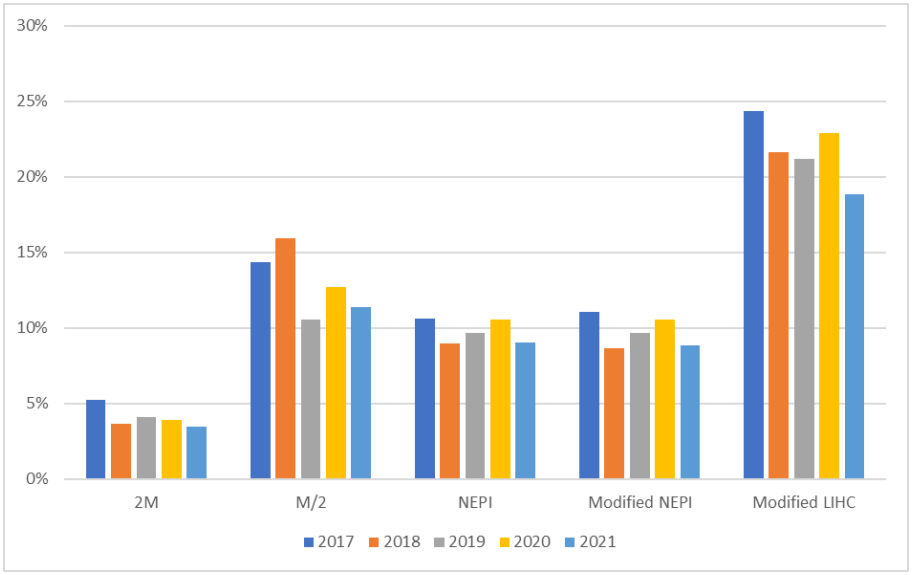

Figure 16. EP levels in the Greek pilot based on five different expenditure indicators for the period 2017-2021.

All the aforementioned EP indicators take into account various aspects of the problem, by integrating individual conditions and adopting specific thresholds to characterize a household as energy-poor.

Changing these thresholds, the estimated levels of energy poverty in a region may be significantly influenced. For example, both the NEPI and the modified NEPI require that a household's equivalised annual net income be less than 60% of the median equivalised income of all households, according to the national definition of relative poverty. In other words, according to these indicators, a prerequisite for a household to be energy-poor is to be classified below the official poverty levels.

Figure 17 and Figure 18 show indicatively how EP levels based on NEPI and the modified NEPI indexes change, by altering the thresholds of the corresponding conditions they incorporate. For example, by using the modified NEPI index and increasing the levelised income threshold to 80% of the median of the corresponding income for all households, which essentially indicates that households above the poverty level may also suffer from energy poverty, the EP rates in the area of interest almost double at 18-20% for the reporting period.

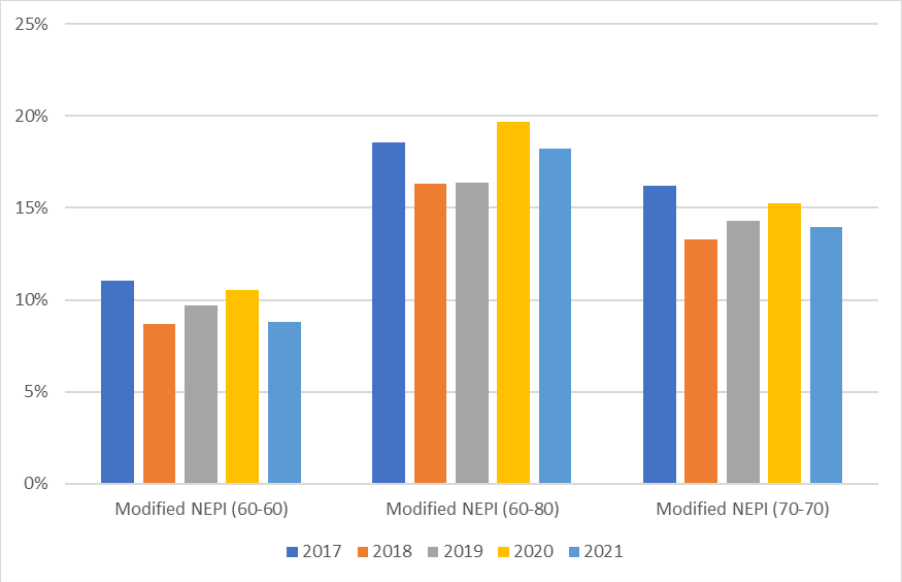

Figure 17. Estimated EP levels based on the modified NEPI index, adopting different thresholds for the two conditions used to structure the index. Condition (i): the threshold of the real in relation to theoretical energy expenditures is set to 60% or 70%. Condition (ii): the threshold of the levelized income in relation to the national median is set to 60%, 70% or 80%.

For all five expenditure EP indicators calculated by HBS data, it is examined how certain housing characteristics and living conditions of households influence the estimated levels of energy poverty.

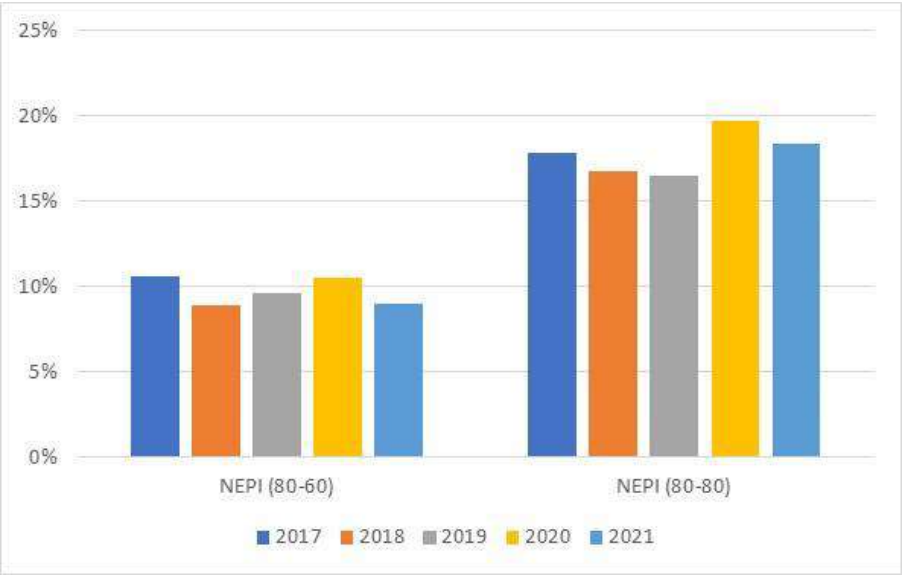

Figure 18. Estimated EP levels based on the NEPI index, for two different levels of the threshold used to control the condition (ii) of the index. Specifically, in the two scenarios examined the threshold of the levelized income in relation to the national median is set to either 60% or 80%.

Figure 19 depicts that the problem of EP is affected primarily by households' income. Specifically, the NEPI as well as the modified NEPI and the modified LIHC indicators clearly show that more

than 2/3 of households belonging to the lowest income categories are characterized as energy poor.

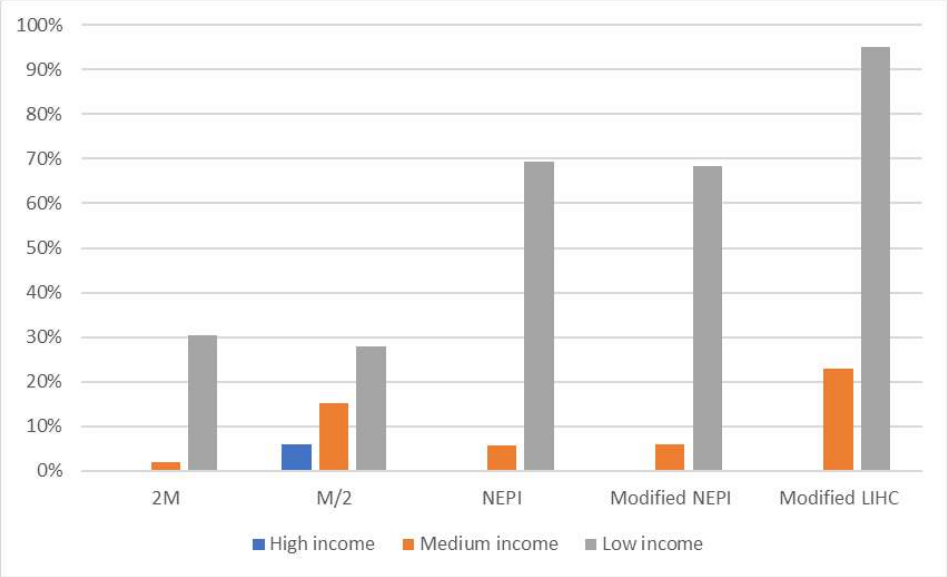

Figure 19. Estimated EP levels using the expenditure indicators in relation to the income class of the households.

The before-mentioned analysis led to the conclusion that **15% of the households are affected by the phenomenon of energy poverty in the Athens Urban Area** taking into account all the examined indicators as the estimated average value.

3 Analysis of the conditions in the pilot area

The Athens Urban Area, also known as “Athens - Piraeus Urban Complex”, forms the core and centre of Greater Athens and stretches across the Attica Basin over an area of 412 km², in Attica, the highest-populated region in Greece (Figure 20).

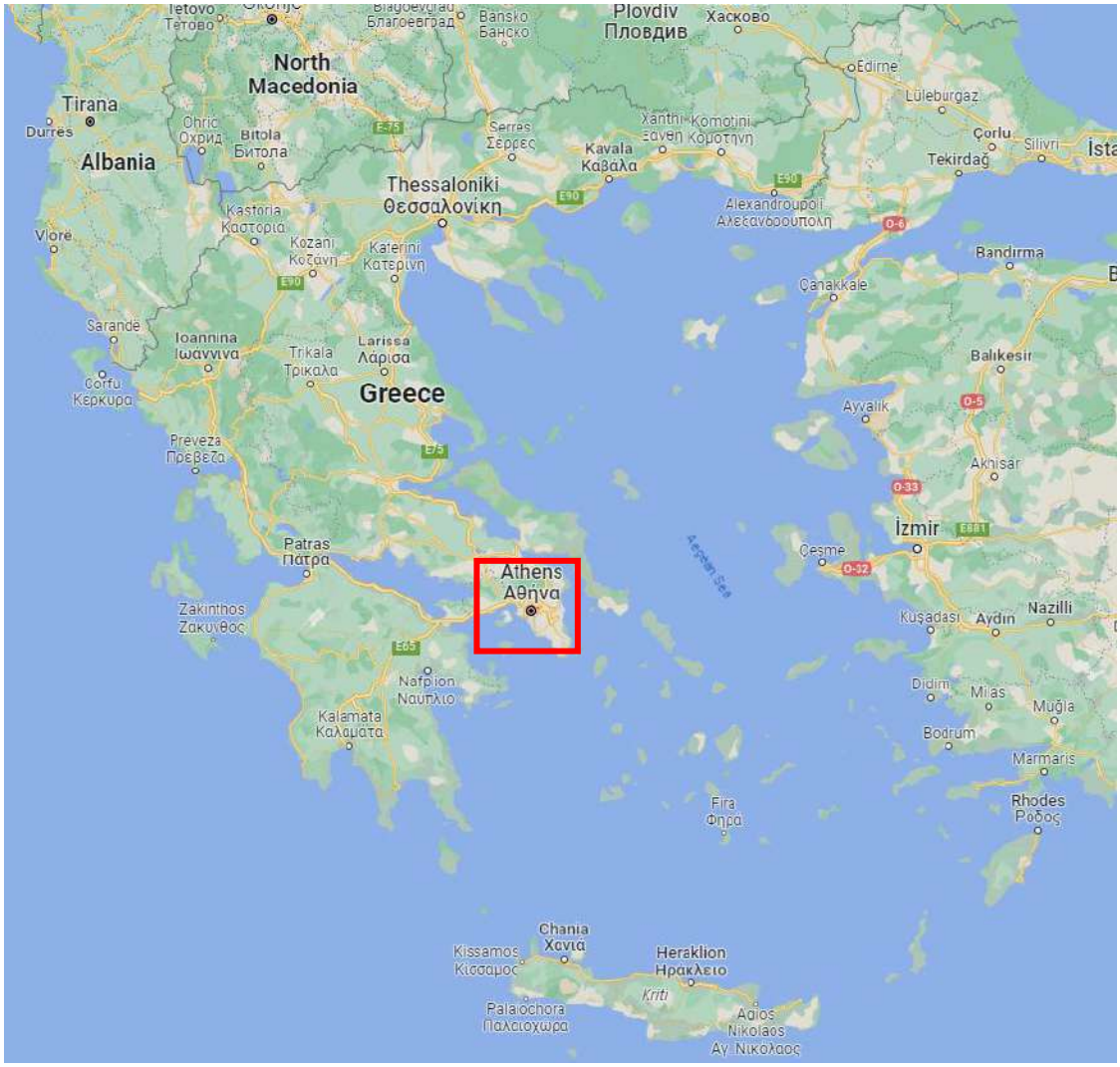

Figure 20. Location of the Greek pilot (Source: Google Maps).

In the new “Athens - Attica Regulatory Plan” (L. 4277/2014, Government Gazette Issue 156A, 01/08/2014), the Athens Urban Area is referred to as the “Athens - Piraeus Spatial Unit”, and consists of 40 municipalities, 35 of which are located within 4 regional units of the former Athens Prefecture (North Athens, West Athens, Central Athens, South Athens), and 5 municipalities are located within the regional unit of the former Piraeus Prefecture, as follows (Figure 21):

- Central Athens Municipalities: Athens, Nea Philadelphia - Nea Chalkidonia, Galatsi, Zografou, Kaisariani, Byronas, Ilioupoli and Daphne - Ymittos.

- North Athens Municipalities: Penteli, Kifissia, Metamorphosis, Lykovrisi - Pefki, Maroussi, Filothei - Psychiko, Papagos - Cholargos, Nea Ionia, Heraklion, Vrilissia, Agia Paraskevi and Halandri.
- South Athens Municipalities: Glyfada, Elliniko - Argyroupoli, Alimos, Nea Smyrni, Moschato - Tavros, Kallithea, Paleo Faliro and Agios Dimitrios.
- West Athens Municipalities: Egaleo, Peristeri, Petroupoli, Haidari, Agia Varvara, Ilion and Agioi Anargyroi - Kamatero.
- Piraeus region Municipalities: Piraeus, Korydallos, Nikaia - Agios Ioannis Rentis, Keratsini - Drapetsona and Perama.

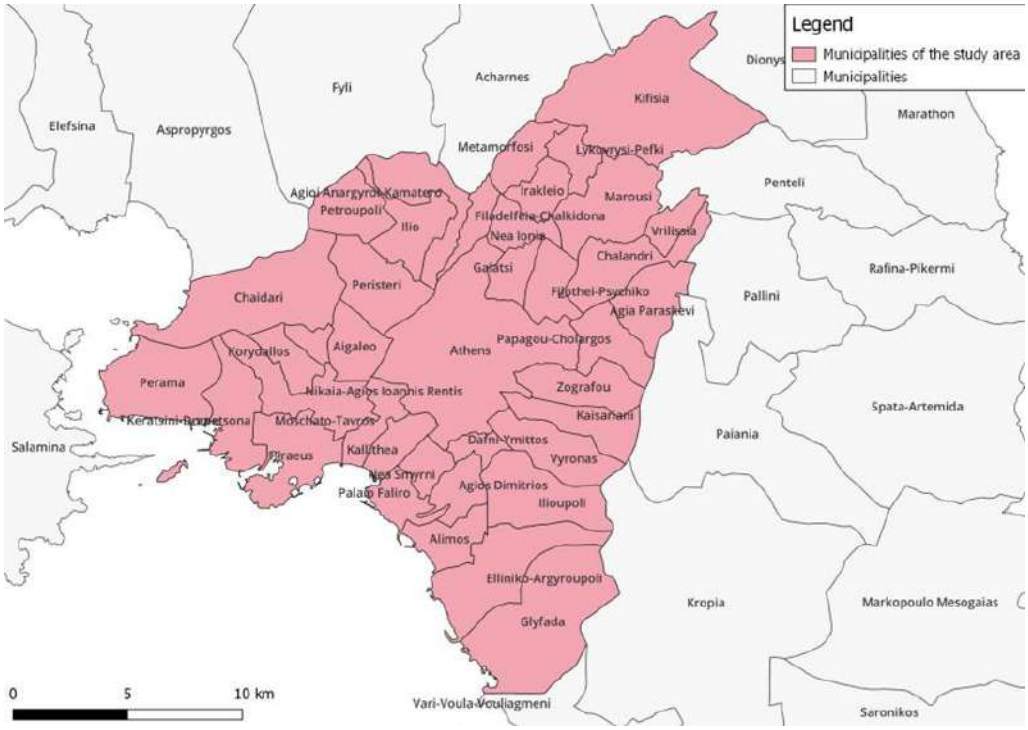

Figure 21. The Athens Urban Area.

The climate of the Area is mild. As shown in Table 3, the average annual temperature over the last 30 years (1991-2020) is 18.5°C, the total annual precipitation is roughly 433 mm, and the average humidity is 61% (Founda & Pierros, 2021).

Table 3. Athens climate data (1991-2020).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Average temp. °C	9.7	10.2	12.5	16.1	21.1	26.0	28.7	28.5	24.1	19.4	14.9	11.1	18.5
Average max °C	13.3	14.2	17	21.1	26.5	31.6	34.3	34.3	29.6	24.4	18.9	14.4	23,3
Average min °C	7.1	7.3	9.2	12.3	17	21.6	24.2	24.4	20.4	16.2	12.2	8.7	15.0
Rainfall mm	55.6	44.4	45.6	27.6	20.7	11.6	10.7	5.4	25.8	38.6	70.8	76.3	433.1
Humidity %	72	70	66	60	56	50	42	47	57	66	72	73	60.9

Source: (Founda & Pierros, 2021)

The following tables (Table 4 and Table 5) present the average HDD and CDD for the study area for the period 2017-2022.

Table 4. HDD for the Greek pilot – monthly data (2017-2022 averages).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
North Athens	311.48	237.22	209.94	97.88	5.92	0.00	0.00	0.00	0.00	6.25	93.80	220.94	1183.42
West Athens	296.79	219.76	188.87	76.75	3.46	0.00	0.00	0.00	0.00	4.54	75.56	205.28	1071.01
Central Athens	285.52	215.84	187.43	84.77	3.21	0.00	0.00	0.00	0.00	2.80	76.39	192.63	1048.59
South Athens	278.35	209.72	180.89	80.61	2.43	0.00	0.00	0.00	0.00	1.85	71.26	184.81	1009.92
Piraeus region	256.96	185.16	155.33	54.18	0.66	0.00	0.00	0.00	0.00	1.33	45.97	165.79	865.38

Source: (Eurostat, 2023a)

Table 5. CDD for the Greek pilot – monthly data (2017-2022 averages).

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
North Athens	0.00	0.00	0.00	0.03	11.48	97.48	194.17	199.23	71.41	3.77	0.00	0.00	577.56
West Athens	0.00	0.00	0.00	0.00	7.07	81.83	175.19	182.93	54.72	1.84	0.00	0.00	503.58
Central Athens	0.00	0.00	0.00	0.21	15.85	108.85	207.93	213.25	80.90	4.70	0.00	0.00	631.67
South Athens	0.00	0.00	0.00	0.00	8.25	93.41	188.37	199.18	70.93	3.25	0.00	0.00	563.38
Piraeus region	0.00	0.00	0.00	0.01	8.93	97.40	192.98	204.47	76.07	3.74	0.00	0.00	583.60

Source: (Eurostat, 2023a)

With a population of over three million (Table 6), the Athens Urban Area is the largest urban conglomeration in Greece, with a high population density (Figure 22).

Table 6. Athens Urban Area permanent population – total and by gender (2021 Census).

Area	Permanent population	Men	Women	Men (%)	Women (%)
Central Athens	**1,002,212**	**480,844**	**521,368**	**48.0**	**52.0**
Athens Municipality	643,452	310,569	332,883	48.3	51.7
Bytonas Municipality	59,134	27,910	31,224	47.2	52.8
Galatsi Municipality	57,909	27,715	30,194	47.9	52.1
Dafnne - Ymittos Municipality	33,886	16,118	17,768	47.6	52.4
Zografou Municipality	69,874	32,790	37,084	46.9	53.1
Illioupoli Municipality	76,730	36,445	40,285	47.5	52.5
Kaisariani Municipality	26,269	12,488	13,781	47.5	52.5
Nea Philadelphia - Nea Chalkidona Municipality	34,958	16,809	18,149	48.1	51.9
North Athens	**601,163**	**283,332**	**317,831**	**47.1**	**52.9**
Maroussi Municipality	71,830	33,516	38,314	46.7	53.3
Agia Paraskevi Municipality	62,147	29,104	33,043	46.8	53.2
Vrilissia Municipality	32,417	15,410	17,007	47.5	52.5
Heraklion Municipality	50,494	24,084	26,410	47.7	52.3
Kifissia Municipality	72,878	34,400	38,478	47.2	52.8
Lykovrisi - Pefki Municipality	30,998	14,782	16,216	47.7	52.3
Metamorphosis Municipality	30,174	14,522	15,652	48.1	51.9
Nea Ionia Municipality	64,611	31,197	33,414	48.3	51.7
Papagos - Cholargos Municipality	45,266	20,651	24,615	45.6	54.4
Penteli Municipality	35,610	17,096	18,514	48.0	52.0
Filothei - Psychiko Municipality	27,636	12,530	15,106	45.3	54.7
Chalandri Municipality	77,102	36,040	41,062	46.7	53.3
West Athens	**478,883**	**232,872**	**246,011**	**48.6**	**51.4**

Area	Permanent population	Men	Women	Men (%)	Women (%)
Peristeri Municipality	133,630	65,077	68,553	48.7	51.3
Agia Varvara Municipality	26,759	12,747	14,012	47.6	52.4
Agioi Anargyroi - Kamatero Municipality	61,462	30,219	31,243	49.2	50.8
Egaleo Municipality	65,831	32,014	33,817	48.6	51.4
Ilion Municipality	84,004	40,833	43,171	48.6	51.4
Petroupoli Municipality	60,146	28,999	31,147	48.2	51.8
Chaidari Municipality	47,051	22,983	24,068	48.8	51.2
South Athens	**529,455**	**249,415**	**280,040**	**47.1**	**52.9**
Kallithea	97,616	45,558	52,058	46.7	53.3
Agios Dimitrios Municipality	71,664	34,624	37,040	48.3	51.7
Alimos Municipality	43,174	20,499	22,675	47.5	52.5
Glyfada Municipality	89,597	42,257	47,340	47.2	52.8
Elliniko-Argyroupoli Municipality	50,027	23,758	26,269	47.5	52.5
Moschato - Tavros Municipality	39,661	19,178	20,483	48.4	51.6
Nea Smyrni Municipality	72,853	33,642	39,211	46.2	53.8
Palaio Faliro Municipality	64,863	29,899	34,964	46.1	53.9
Piraeus region	**448,051**	**216,823**	**231,228**	**48.4**	**51.6**
Piraeus Municipality	168,151	80,642	87,509	48.0	52.0
Keratsini - Drapetsona Municipality	89,536	43,247	46,289	48.3	51.7
Korydallos Municipality	61,248	30,257	30,991	49.4	50.6
Nikaia - Agios Ioannis Rentis Municipality	103,488	50,061	53,427	48.4	51.6
Perama Municipality	25,628	12,616	13,012	49.2	50.8

Source: (Hellenic Statistical Authority, 2023b)

About 48% are men and 52% are women. A worrisome finding is that the population of the Attica Region, and consequently of the pilot area, is ageing, as shown in Figure 23. In line with this fact, the share of one-person households (34.8% in total) has increased by around 37% and that of two-person households (27.4% in total) by 4%, while three-person (18.7% in total), four-person (14.6% in total) and five or more-person (4.6% in total) households have decreased by 2.3%, 10.7% and 9.9%, respectively (Hellenic Statistical Authority, 2023a).

The Athens Urban Area is the political, economic, and maritime centre of Greece, with a large financial sector, and the port Piraeus, which is the largest passenger port as well as one of the largest container ports in Europe. In absolute terms, the Gross Domestic Product (GDP) of the Athens Urban Area was 65.95 billion € in 2020, accounting for about 40% of the whole Greek economic output. The GDP per capita was more than 21,500 € or 140% of the national average in the same year, and the unemployment rate stood at 14.2% (national unemployment rate: 16.3%).

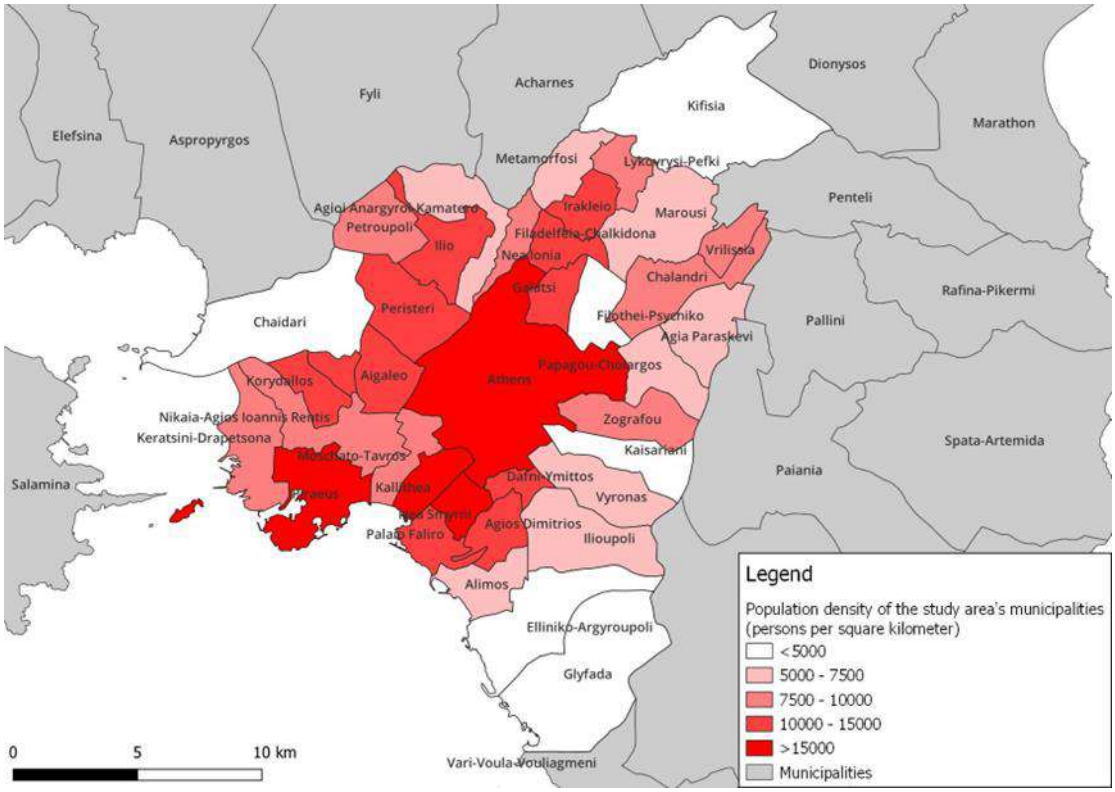

Figure 22. Population density in Athens Urban Area.

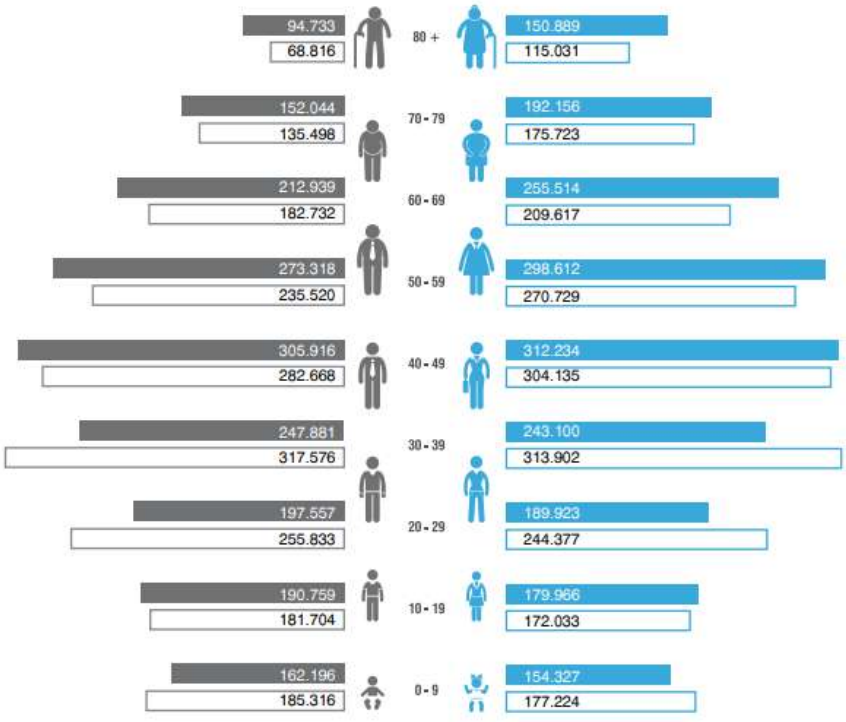

Figure 23. Permanent population by gender and age groups in the Region of Attica (Source: (Hellenic Statistical Authority, 2023a).

Detailed data for the years 2017-2021 are presented in Table 7 and Table 8. The richest regions are Central and North Athens and the poorest is West Athens, whereas South Athens and Piraeus region stand in the middle. Significant income inequalities are also observed within the Athens Urban Area regions. Compared to Central Athens, which is the richest region in the study area, the GDP per capita in North Athens is around 82%, in South Athens and Piraeus about 59%, and in West Athens only 35%.

Table 7. GDP per capita at current market prices in Athens Urban Area.

	2017	2018	2019	2020	2021
Greece	16,400	16,700	17,100	15,500	17,000
Attiki	22,500	22,900	23,400	21,100	23,000
North Athens	26,800	26,800	28,000	25,700	--
West Athens	11,400	11,600	11,900	10,600	--
Central Athens	32,500	33,100	33,800	30,500	--
South Athens	19,100	19,500	20,100	18,100	--
Piraeus region	19,000	19,500	20,000	18,100	--

Source: (Eurostat, 2023b)

Table 8. GDP per capita in Athens Urban Area in relation to the national GDP per capita.

	2017	2018	2019	2020	2021
Attiki	137.2%	137.1%	136.8%	136.1%	135.3%
North Athens	163.4%	160.5%	163.7%	165.8%	--
West Athens	69.5%	69.5%	69.6%	68.4%	--
Central Athens	198.2%	198.2%	197.7%	196.8%	--
South Athens	116.5%	116.8%	117.5%	116.8%	--
Piraeus region	115.9%	116.8%	117.0%	116.8%	--

Source: (Eurostat, 2023b)

4 Analysis of the building stock

4.1 Overview of the building stock for the targeted building types

The latest Greek Housing Census was conducted from July to October 2021, but the results have not yet been released. Therefore, the description of housing characteristics was based on the previous census, which was conducted in 2011, regarding the number of houses, the construction period and the size (number of rooms and size in m^2).

The energy performance characteristics of the buildings, however, are based on the 2011 Greek Housing Census and the statistical results of the Energy Performance of Buildings Certificates, which are presented annual and quarterly basis for the Hellenic Territory by the Ministry of Environment and Energy (https://bpes.ypeka.gr/?page_id=21&stat=222).

Based on the 2011 Greek Housing Census, the total number of residences is around 1,662,500. About 37.6% are located in Central Athens, 17.2% in North Athens, 14.2% in West Athens, 16.6% in South Athens, and 14.4% in Piraeus region.

As far as the construction period is concerned (Table 9), 62% of the houses were built before the implementation of thermal requirements and energy-related building codes (before 1980).

Table 9. Number of residences by construction period in Athens Urban Area.

	Total no. of houses	Construction period							
		Before 1945	1946 - 1960	1961 - 1970	1971 - 1980	1981 - 1990	1991 - 2000	2001 - 2005	After 2006
Central Athens	625,811	14,240	63,060	195,254	194,064	55,057	40,765	33,929	29,442
North Athens	286,087	3,967	16,006	28,309	79,096	60,976	49,486	25,511	22,736
West Athens	235,730	2,826	20,099	43,541	71,765	38,486	26,474	17,797	14,742
South Athens	275,396	2,945	15,112	44,066	88,305	47,716	36,603	21,424	19,225
Piraeus region	239,485	9,235	20,346	45,877	72,009	30,590	21,325	21,473	18,630

Table 10. Number of residences by size (in m^2) in Athens Urban Area.

Area	Total no. of houses	Area (m^2)									
		Less than 40	40-49	50-59	60-69	70-79	80-89	90-99	100 -109	110 -119	120+
Central Athens	625,811	55,298	53,683	103,738	72,136	109,834	80,539	52,799	38,668	20,602	38,514
North Athens	286,087	7,948	9,238	20,053	19,451	31,231	36,876	28,623	31,230	22,174	79,263
West Athens	235,730	11,334	14,202	26,494	28,438	40,740	40,893	28,109	20,072	9,488	15,960
South Athens	275,396	13,383	13,901	30,002	25,090	40,328	42,481	29,911	26,416	16,422	37,462
Piraeus region	239,485	11,670	15,695	29,922	31,830	43,854	40,173	25,529	17,260	8,719	14,833

The area with the oldest houses is Central Athens (around 75% of the houses were built before 1981), followed by the Piraeus region (about 62% of the houses were built before 1981). North Athens, on the other hand, shows the lowest percentage of old buildings (around 44.5%). West and South Athens lie in the middle, i.e., the pre-1981 houses make up 58.6% and 54.6%, respectively.

According to Table 10, 12.4% of dwellings are less than 50 m^2, 39.3% between 50 and 79 m^2, 32.5% between 80 and 109 m^2, and the rest (i.e., 15.8%) more than 110 m^2. Most of the houses in Central Athens are small and in North Athens large. In the other areas, there is, more or less, a more even distribution of dwelling sizes (Figure 24).

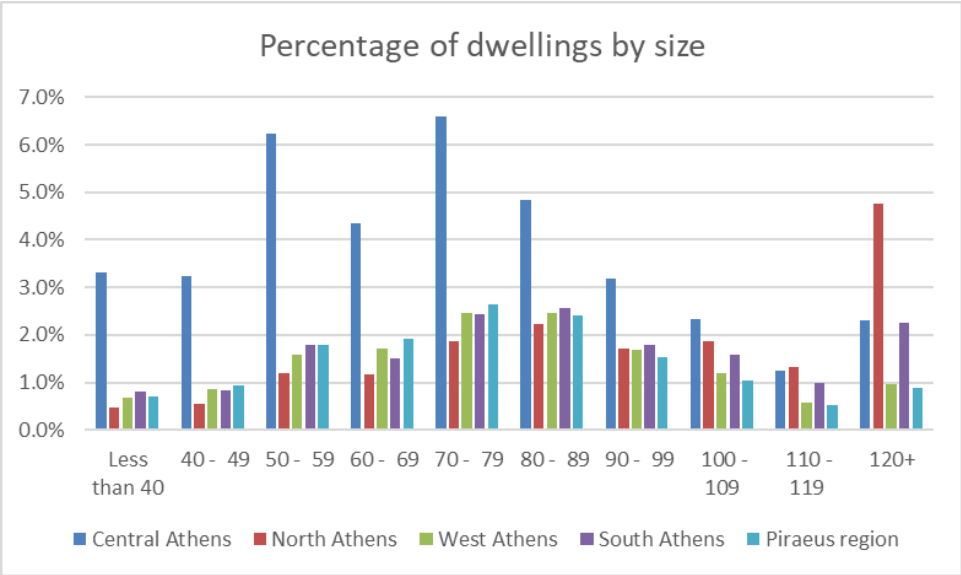

Figure 24. Distribution of dwellings by size and regions in Athens Urban Area.

A similar pattern is observed relative to the number of rooms. Specifically, 6.6% of dwellings have one room (apart from the kitchen and bathroom), 26.7% have two rooms, 42% three rooms, 19.2% four rooms, and the rest 5+ rooms. Central Athens, as expected, has the highest percentage of small dwellings (one or two rooms), as well as of dwellings with three rooms out of the total number of dwellings (Figure 25).

Table 11. Number of residences by number of rooms in Athens Urban Area.

	Total no. of houses	Number of rooms					
		1	2	3	4	5	6+
Central Athens	625,811	58,294	203,407	249,166	90,276	18,309	6,359
North Athens	286,087	9,644	47,525	110,734	84,549	21,758	11,877
West Athens	235,730	12,910	59,440	109,256	45,150	6,604	2,370
South Athens	275,396	15,133	64,859	117,940	61,125	12,210	4,129
Piraeus region	239,485	13,429	68,709	111,701	37,451	6,183	2,012

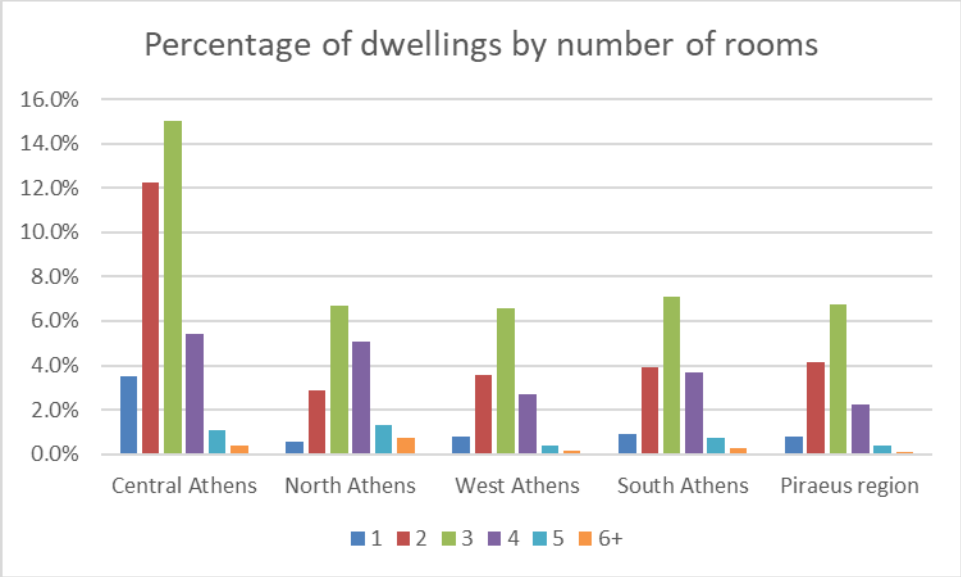

Figure 25. Distribution of dwellings by number of rooms and regions in Athens Urban Area.

4.2 Presentation of data from the energy performance certificates per building type

According to the results of the 2011 Housing Census, in the total of dwellings of the Athens Urban Area, 883,948 dwellings (53.2%) have some kind of insulation, while 778,561 dwellings (46.8%) have no insulation. Table 12 below shows the percentage of the type of insulation of the dwellings by regional area in the pilot. Specifically, 25.3% have double-glazing windows, 9.9% have insulated walls/roofs, and 18% have two or more insulation types (e.g., double-glazing windows and insulated walls).

Table 12. Number of houses by type of insulation in Athens Urban Area.

	Total no. of houses	Energy efficiency measures			
		Double glazing	External wall insulation	Two or more insulation types	No insulation
Central Athens	625,811	139,497	64,473	69,405	352,436
North Athens	286,087	81,757	30,915	87,377	86,038
West Athens	235,730	63,411	20,212	46,495	105,612
South Athens	275,396	75,807	28,155	55,839	115,595
Piraeus region	239,485	60,907	20,168	39,530	118,880

In order to get a more recent picture of the energy efficiency situation of the dwellings in the area of interest, statistics from the Energy Performance of Buildings Certificates (EPBC) are presented below, which were retrieved from the Ministry of Environment and Energy (https://bpes.ypeka.gr/?page_id=21&stat=222). The analysis is based on more than 797,000 EPBCs issued in the period 2011-2021.

According to Table 13, about 62% of primary energy consumption is used for heating, 21.8% for domestic hot water (DHW), 16.2% for cooling and less than 0.01% for lighting. Moreover, only 0.02% of primary energy consumption is produced by RES.

Table 13. Average primary energy consumption (kWh/m^2) by region, type of building and energy use in Athens Urban Area.

	Heating	Cooling	Lighting	DHW	RES participation	Total primary energy consumption
Athens region	**151.10**	**39.51**	**0.00**	**53.21**	**0.05**	**243.77**
Apartment	147.16	38.52	0.00	53.70	0.03	**239.34**
SFH	256.85	64.33	0.00	44.51	0.21	**365.49**
MFH	138.81	43.64	0.00	38.03	0.94	**219.55**
Piraeus region	**157.88**	**42.13**	**0.00**	**52.37**	**0.03**	**252.34**
Apartment	143.75	39.89	0.00	52.34	0.01	**235.97**
SFH	310.84	65.94	0.00	53.27	0.17	**429.87**
MFH	192.03	50.31	0.00	48.75	0.28	**290.81**

As presented in Table 14, more than 71% of dwellings in the area of the Greek pilot are classified in the three worst energy classes (E, F and G), about 25% in the middle energy classes (C & D), and about 4% in the highest energy classes (A+ to B). It should be noted that some newly constructed dwellings are classified in low energy category E because the year of issue of the building permit was before the date of entry into force of the building insulation regulation issued in 2010 (known as KENAK), while their construction was completed in the period 2011-2021.

Table 14. Number of EPBCs by region, type of building and energy class.

	Energy class									
	A+	A	B+	B	C	D	E	F	G	Total
Athens region	**877**	**1,666**	**5,866**	**16,786**	**66,205**	**84,445**	**90,361**	**130,300**	**210,848**	**607,354**
Apartment	599	1,210	4,856	15,362	63,886	81,322	87,802	127,389	196,814	**579,240**
SFH	39	124	436	732	1,817	2,609	2,104	2,361	11,970	**22,192**
MFH	239	332	574	692	502	514	455	550	2,064	**5,922**
Piraeus region	**34**	**140**	**758**	**2,716**	**10,237**	**11,455**	**12,338**	**16,866**	**34,372**	**88,916**
Apartment	20	104	637	2,498	9,923	10,921	11,636	15,928	29,039	**80,706**
SFH	10	9	79	151	229	431	589	817	4,766	**7,081**
MFH	4	27	42	67	85	103	113	121	567	**1,129**
Total	**911**	**1,806**	**6,624**	**19,502**	**76,442**	**95,900**	**102,699**	**147,166**	**245,220**	**696,270**

Of particular interest are the following tables (Table 15 and Table 16), which analyse the results of the energy upgrading of houses that participated in the programmes “Exoikonomo I and II”, “Exoikonomo – Autonomo” and “Exoikonomo 2021”. In these dwellings, it is observed that the largest percentage, after the energy interventions, is classified in energy categories C, D and E. From the year 2021, the energy interventions lead to dwellings in energy categories B to A+ (Hellenic Ministry of Environment and Energy, 2022).

From all these figures, it is worth noting the energy-saving potential of the three lowest energy classes (E, F and G), which ranges from 21% (when houses are upgraded by a maximum of one energy class) to around 96% (when they are upgraded to the highest energy class).

Table 15. Average annual energy consumption (kWh/m^2) of residential buildings by energy category before and after energy interventions.

Before (S1)	After (S2)																	
	A+		A		B+		B		C		D		E		F		G	
	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2	S1	S2
B					90.40	89.85												
C	173.50	19.60	192.61	63.29	159.32	119.26			147.40	144.04								
D	238.24	26.31	217.75	56.89	221.51	114.48	223.42	85.74	219.76	148.29	237.30	163.19						
E	224.84	19.90	260.30	52.83	265.87	111.49	273.23	83.49	260.61	148.70	261.39	192.02	289.92	212.60				
F	368.42	20.65	319.13	51.98	325.05	110.08	328.49	81.35	311.01	147.95	300.24	188.64	297.93	232.74	339.46	267.09		
G	512.95	22.08	522.38	51.57	556.02	117.74	570.95	85.22	516.94	157.55	491.82	202.48	477.31	250.01	476.52	300.79	627.49	435.23

Table 16. Energy savings after energy interventions.

Before (S1)	After (S2)								
	A+	A	B+	B	C	D	E	F	G
	S2	S2	S2	S2	S2	S2	S2	S2	S2
B			-0.6%						
C	-88.7%	-67.1%	-25.1%		-2.3%				
D	-89.0%	-73.9%	-48.3%	-61.6%	-32.5%	-31.2%			
E	-91.1%	-79.7%	-58.1%	-69.4%	-42.9%	-26.5%	-26.7%		
F	-94.4%	-83.7%	-66.1%	-75.2%	-52.4%	-37.2%	-21.9%	-21.3%	
G	-95.7%	-90.1%	-78.8%	-85.1%	-69.5%	-58.8%	-47.6%	-36.9%	-30.6%

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

According to the available data for 2021 (Figure 26), 53% of the consumed final energy was utilized for space heating in residential buildings, while lighting and electrical appliances had the second highest share (20%). The production of domestic hot water amounted to 14% of the final energy consumption while cooking and space cooling presented correspondingly lower shares (9% and 4% respectively).

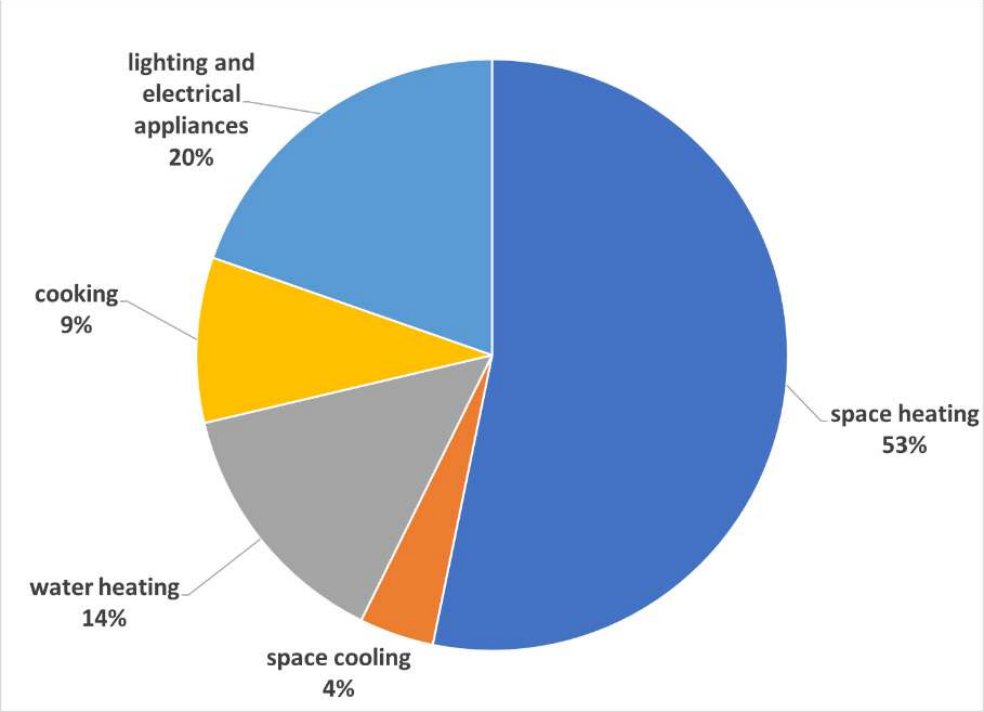

Figure 26. Allocation of the final energy consumption to the various end-uses.

Lighting and electrical appliances had more than half of the consumed electricity, while the other end-uses resulted in shares ranging from 8% for the case of space heating to 16% for the case of domestic hot water (Figure 27).

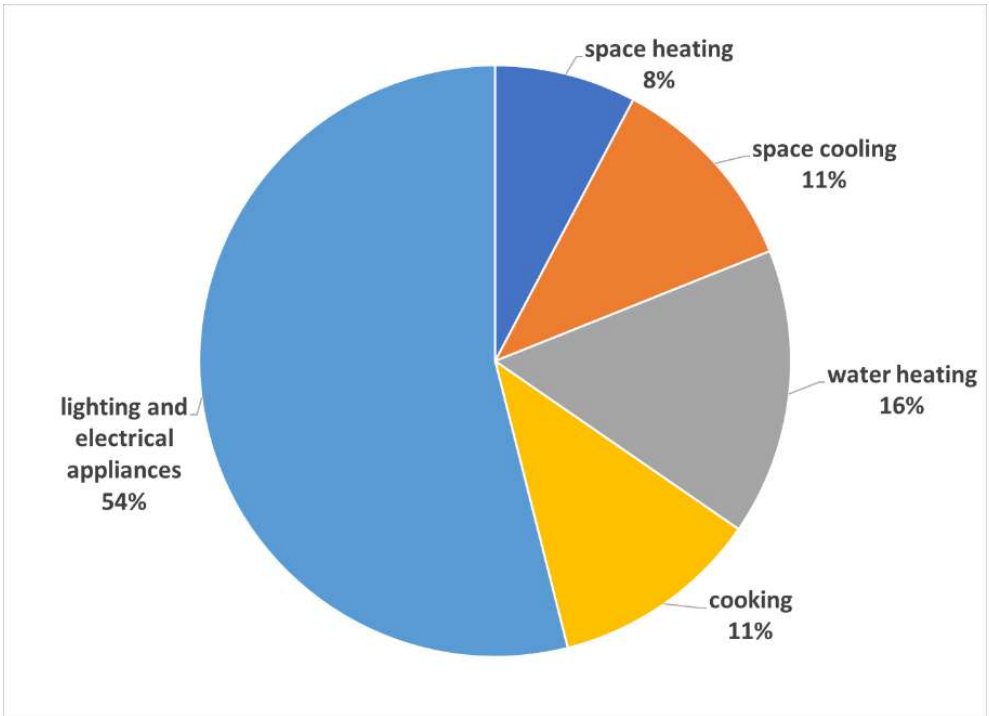

Figure 27. Allocation of the electricity consumption to the various end-uses.

Electricity was the most prevailing energy carrier representing 36% of the total energy consumption according to the presented data in Figure 28. Oil and petroleum products had also a significant share (26%), while the penetration of biofuels and natural gas was also notable with shares equal to 16% and 12% respectively. The shares of the other energy carriers were low ranging from 1% to 7%.

Oil and petroleum products had the highest share in space heating (44%), while the shares of biofuels and natural gas amounted to 23% and 22% highlighting their significant role (Figure 29). The shares of the other energy carriers were low ranging from 2% to 5%.

According to Figure 30, the contribution of solar thermal to the production of domestic hot water was the highest one (49% share), while electricity had also a remarkable penetration (41% share). Oil and petroleum products and natural gas revealed considerably lower shares (9% and 1% respectively).

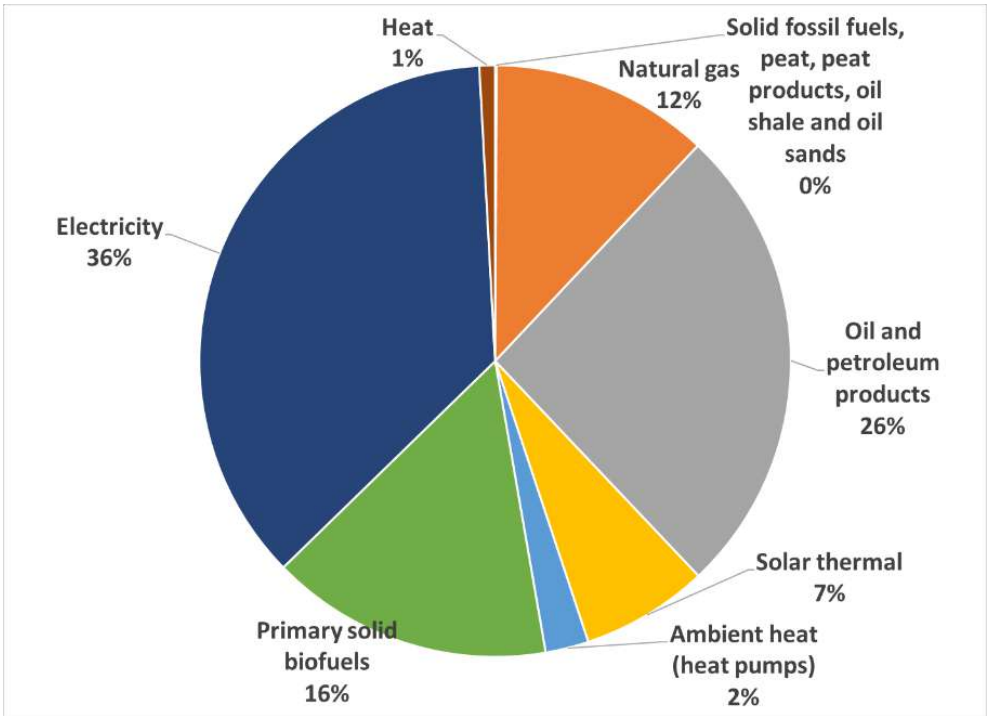

Figure 28. Allocation of the final energy consumption to the various energy carriers.

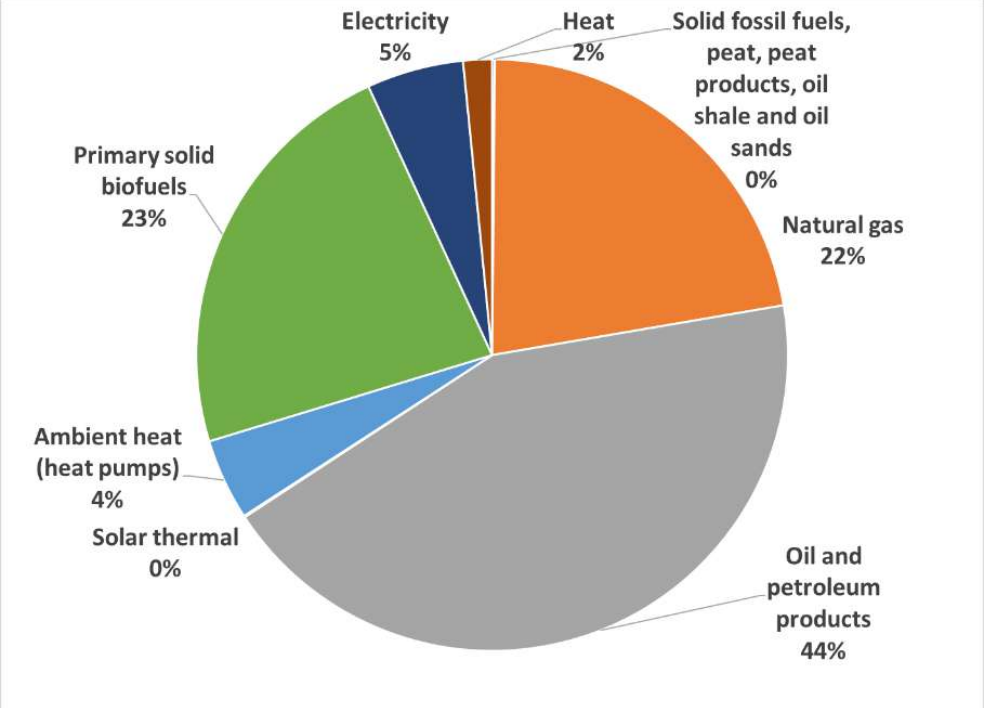

Figure 29. Allocation of the energy consumption for space heating to the energy carriers.

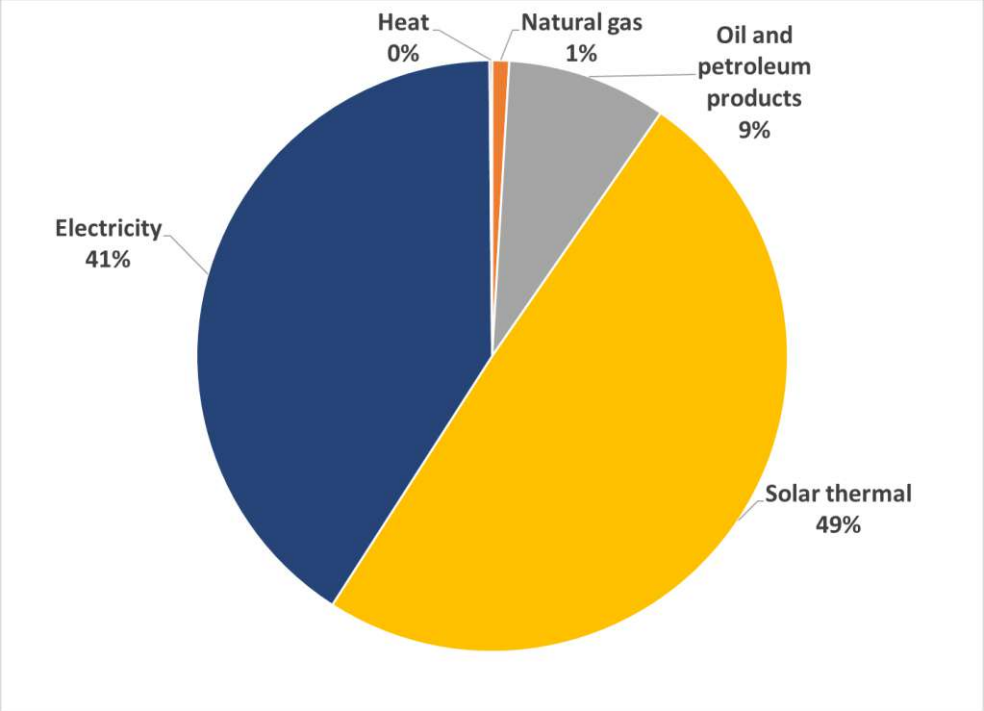

Figure 30. Allocation of the energy consumption for domestic hot water to the various energy carriers.

Electricity was the most common energy carrier for cooking (46% share), while biofuels constituted an alternative option representing 37% of the consumed energy (Figure 31). Finally, oil and petroleum products were utilized with a considerably lower share (17% respectively).

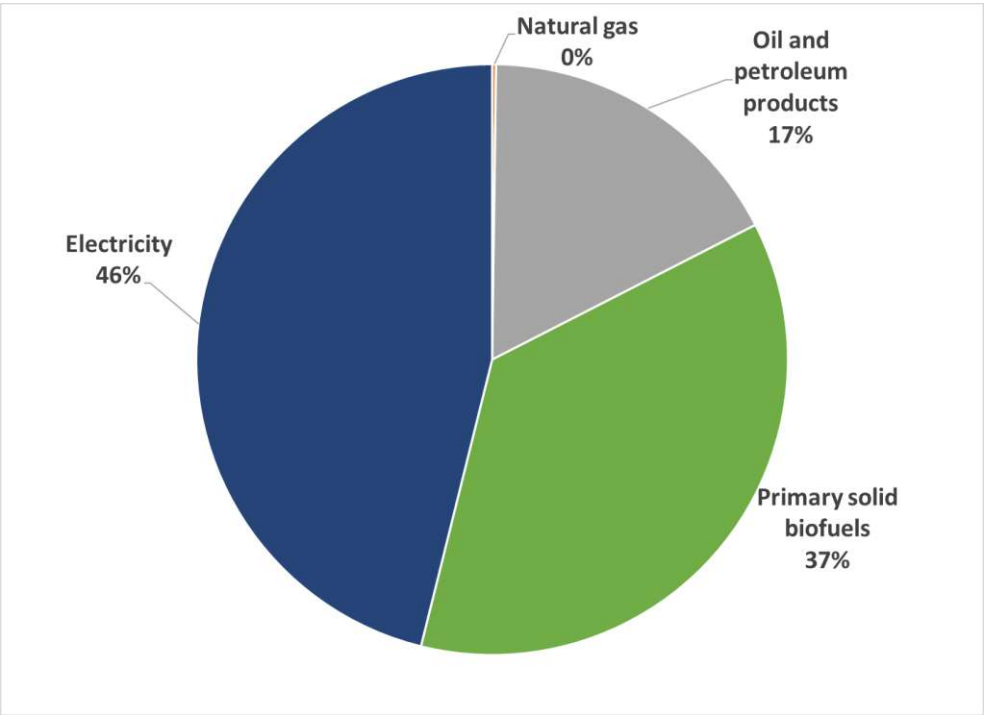

Figure 31. Allocation of the energy consumption for cooking to the various energy carriers.

4.4 Analysis of the energy poverty levels per building type

The EP indicators are investigated for certain housing features and living conditions to explore the effect of the last ones on EP vulnerability in the pilot area. As shown in Figure 32, households living in detached and semi-detached or terraced houses are more prone to almost all EP indicators (arrears, leaks, inability to keep home warm), with a focus on the problem of leaks, probably due to the more indoor-outdoor spaces and open-to-air walls of these buildings, which makes it difficult to heat sufficiently a building.

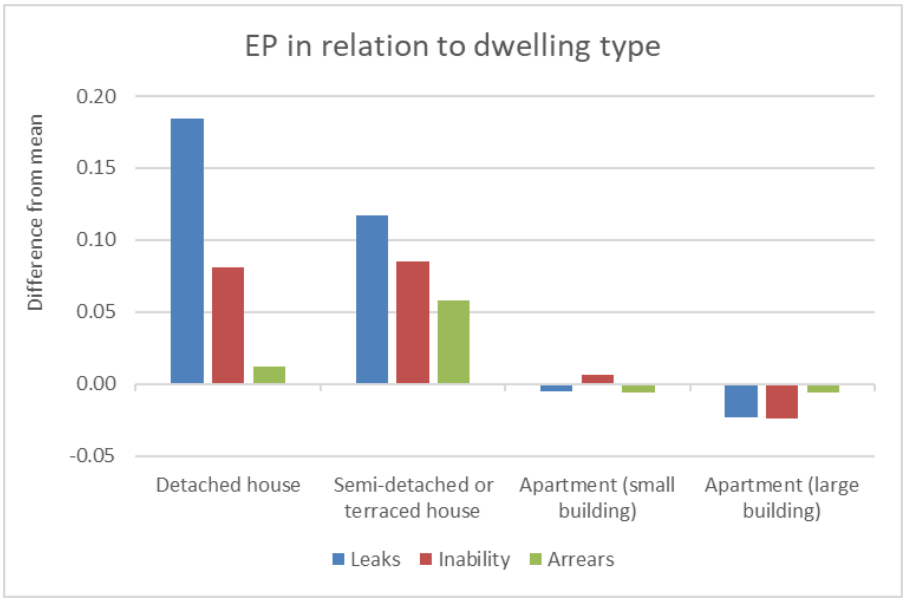

Figure 32. Leaks, inability to keep the house warm and arrears on utility bills in relation to dwelling type.

The relationship of EP indicators with the dwelling size is illustrated in Figure 33. Households living in one- or two-room houses present higher EP rates compared to the average, i.e., there appear mainly problems with leaks, followed by arrears and inability to keep the home warm, while households living in houses with four or more rooms have lower EP rates.

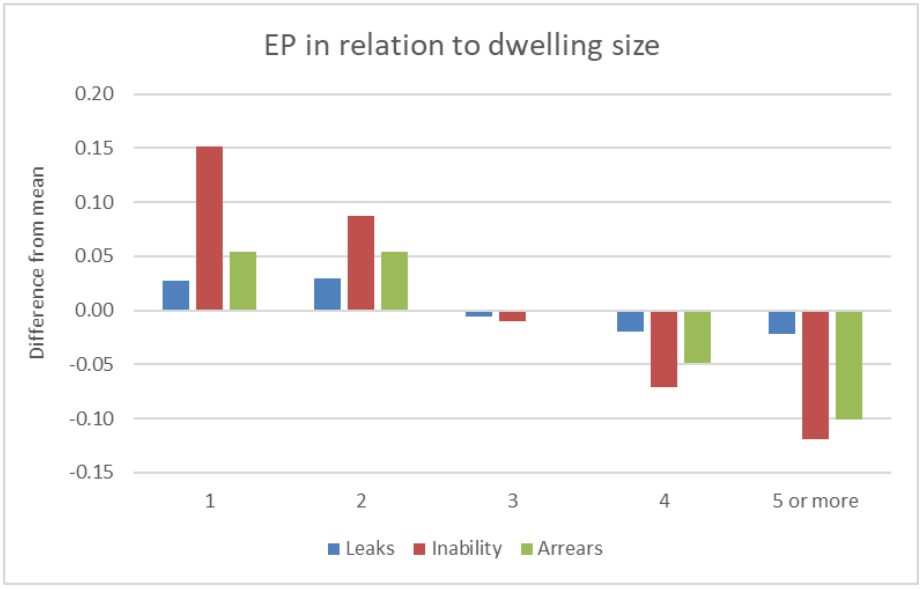

Figure 33. Leaks, inability to keep the house warm and arrears on utility bills in relation to dwelling size.

Similar trends are detected when examining the complementary EP indicators. More specifically, the highest EP rates compared to the average are shown in the case of households living in detached and semi-detached or terraced houses (Figure 34), in the case of those living in one- or two-room homes (Figure 35), in the case of tenants at reduced rates (Figure 36).

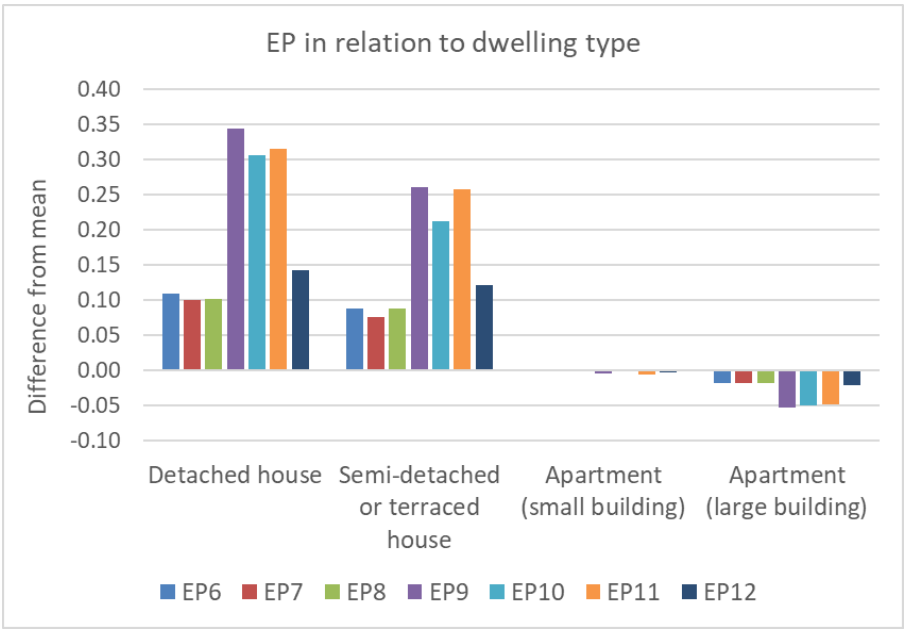

Figure 34. Complementary EP indicators in relation to dwelling type.

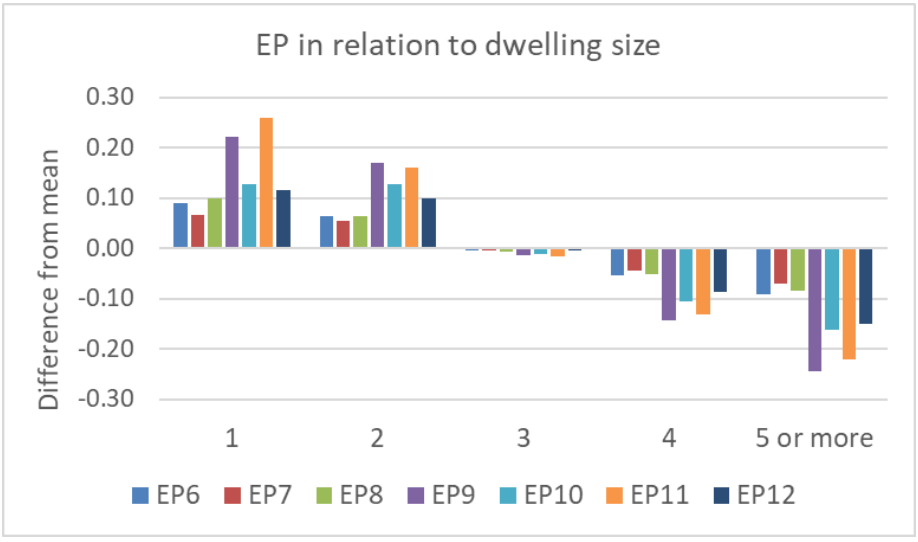

Figure 35. Complementary EP indicators in relation to dwelling size.

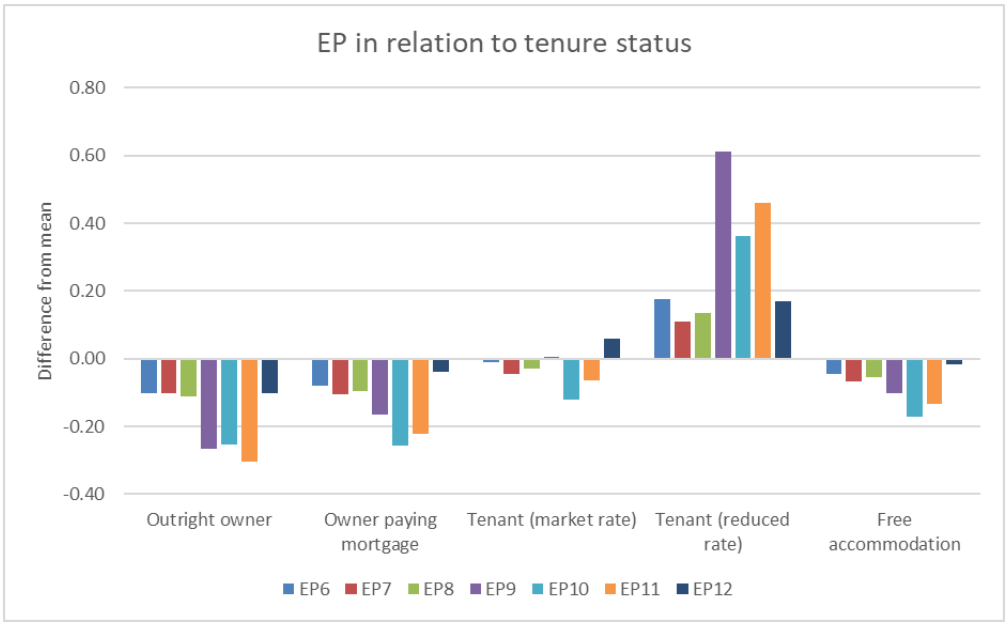

Figure 36. Complementary EP indicators in relation to tenure status.

As regards tenure status, the most vulnerable groups to EP are tenants (mainly those at reduced rates, followed by those at market rate) (Figure 37).

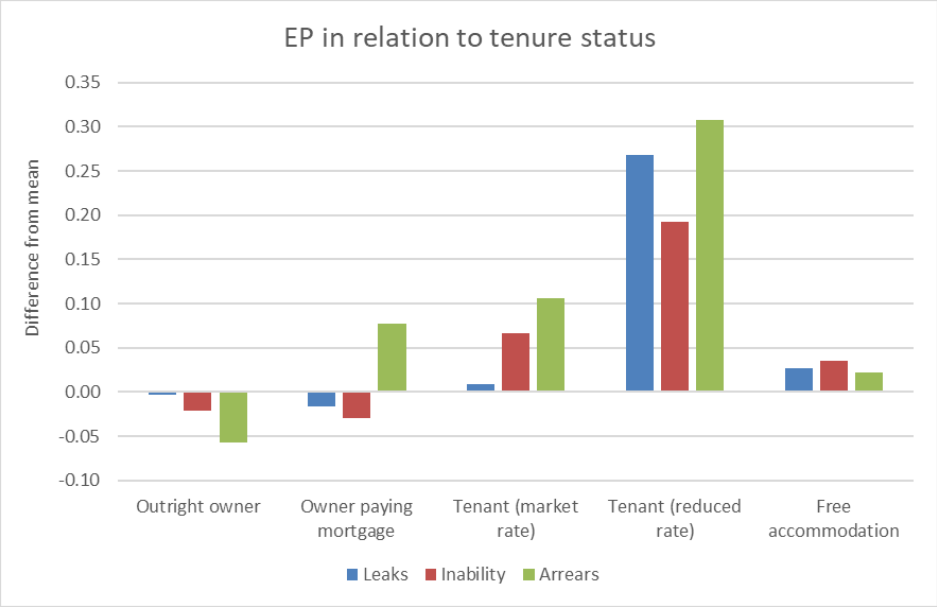

Figure 37. Leaks, inability to keep the house warm and arrears on utility bills in relation to tenure status.

As expected, households that pay rent for their housing show higher levels of EP than households that live in owner-occupied housing according to all EP indicators considered (Figure 38). It is also noteworthy that according to both NEPI and modified NEPI indices, the highest levels of EP occur in households, in which accommodation is provided for free by family or third parties. These are probably young families, at the beginning of their working life, with low incomes and perhaps high levels of unemployment.

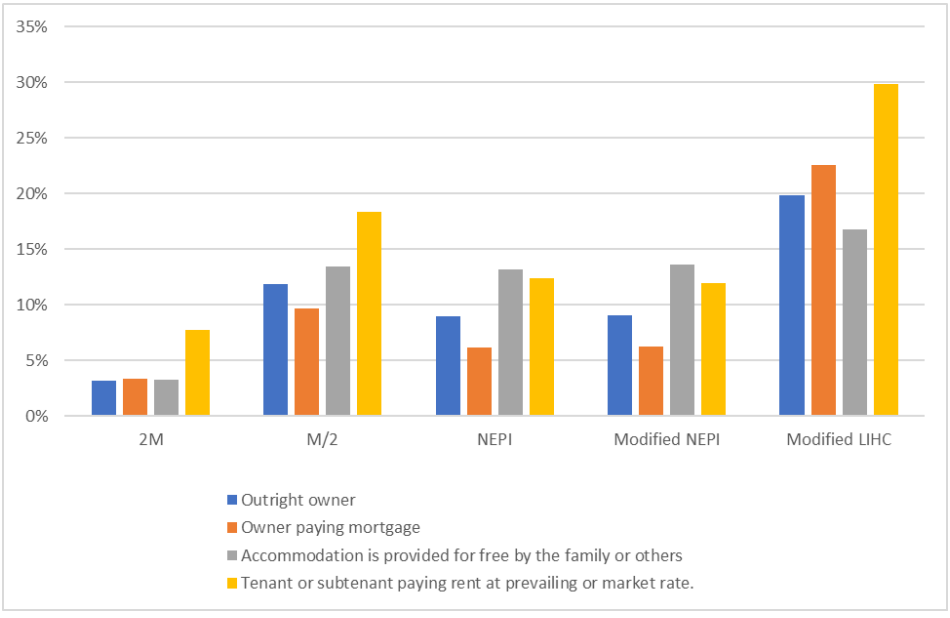

Figure 38. Estimated EP levels using the expenditure indicators in relation to tenure status.

As can be seen in Figure 39, EP levels are lower in households that live in apartments compared to those that live in detached or semi-detached houses. This is probably attributed to the fact that

apartments generally have lower energy losses than single-family houses, and thus they require relatively lower expenditures to ensure adequate thermal comfort conditions. In addition, all indicators examined show that EP levels are lower in small apartment buildings. This probably has to do with the fact that the residents of relatively small multi-family buildings can more easily communicate with each other and agree to operate the central heating system that these buildings usually have. On the contrary, such an agreement is more difficult to achieve in large buildings with many occupants, which leads every household to look for alternative and usually inefficient ways of heating.

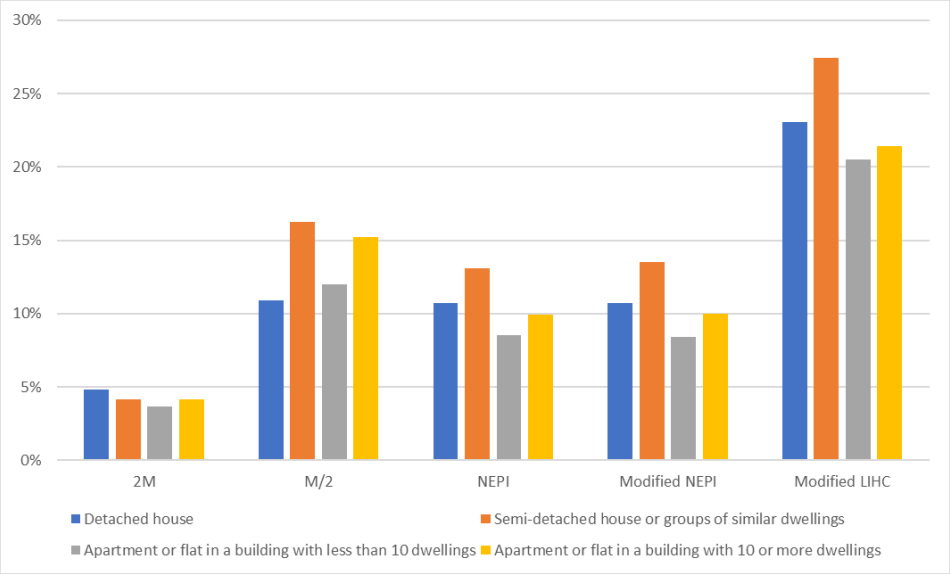

Figure 39. Estimated EP levels using the expenditure indicators in relation to dwelling type.

As a general trend, EP levels are higher in households living in small houses with a relatively small number of rooms (Figure 40). This is probably attributed to the fact that low-income households usually live in small-sized houses with a limited number of rooms. However, two of the examined indicators show an increase in EP levels in households living in residences with many rooms, demonstrating the high energy costs required to ensure adequate thermal comfort conditions in these dwellings.

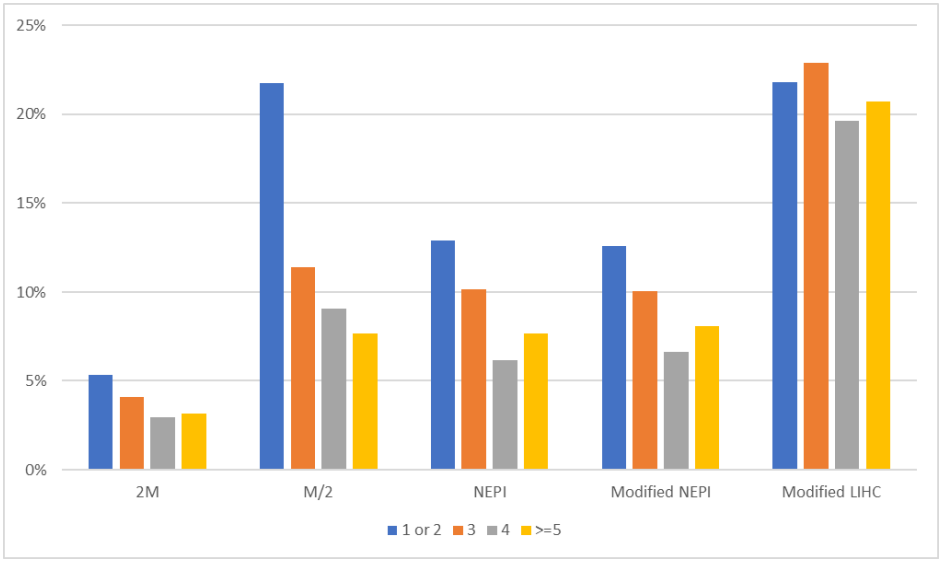

Figure 40. Estimated EP levels using the expenditure indicators in relation to the size of the dwellings and the number of rooms.

Figure 41 clearly shows that EP is directly linked to the year of construction of the households' residence and therefore to their energy performance. Specifically, based on all indicators examined (except 2M) the EP levels are significantly reduced in households living in dwellings built after 1980, when the first national Thermal Insulation Regulation came into force. As regards the EP levels of households living in houses built after 1980, they are affected both by the continued improvements in the energy performance of buildings as well as by the increases in the surface area of new homes. In any case, improving the energy efficiency of the building stock is a basic condition for structurally addressing the problem of energy poverty.

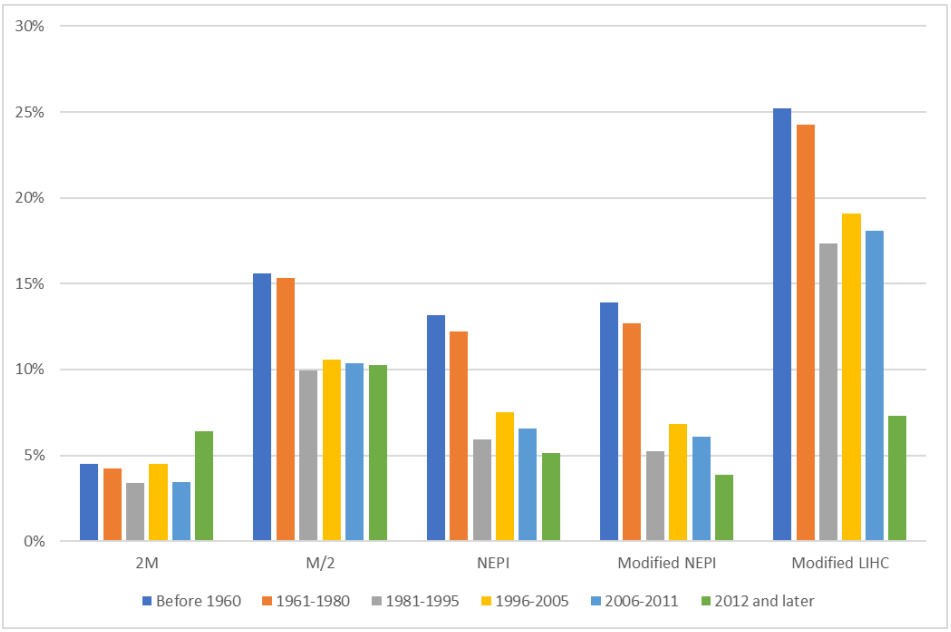

Figure 41. Estimated EP levels using the expenditure indicators in relation to the construction year of the dwelling.

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

Currently, various building renovation programmes have already been implemented.

In 2021, the "Exoikonomo 2021" programme began, financed under the framework of the National Recovery and Resilience Plan Greece 2.0 with funding from the European Union – NextGenerationEU. The "Exoikonomo 2021" is a residential energy upgrade program, which is the successor scheme of the "Exoikonomo kat' Oikon" and "Exoikonomo-Autonomo" programs, with a total budget of 632 million €. In 2023, the successor of the programme "Exoikonomo 2021", namely "Exoikonomo 2023" was announced. The programme concerns buildings that have a building permit or other legal document, they are used as a main residence and whose owners meet specific income criteria. The design of the programme takes into account the integrated approach of energy-saving interventions in the domestic building sector and aims to (a) reduce the energy needs of buildings and pollutant emissions that contribute to the worsening of the greenhouse effect, (b) achieve cost savings for citizens, improving daily living conditions and comfort as well as their safety and health when using these buildings and (c) attain a cleaner environment. The program aims to improve the energy class of households by at least 3 energy classes (over 30% of primary energy saving). The "Exoikonomo" programmes will contribute to energy savings of at least 213 ktoe per year and the energy renovation of at least 105,000 homes by 2025. Particular care is taken to support poor and vulnerable households in the form of an increased grant rate and a separate budget of 100 million € and EUR 60 million €, in "Exoikonomo 2021" and "Exoikonomo 2023", respectively.

The first round of the "Exoikonomo 2023" has led to the renovation of approximately 32 thousand buildings with a total budget equal to 422 million €. The second round of the "Exoikonomo 2023" programme was announced at the beginning of 2024 focusing on the alleviation of energy poverty with the provision of 110 million € as economic support.

Also in 2023, the Greek State announced the "Photovoltaic on the roof" Programme with a total budget of over 200 million €. The Programme aims to install PV in combination with battery systems, to bring the building stock to near-zero energy consumption standards by 2050, and to lower living costs. The Programme subsidises households for the installation of PV systems with storage and farmers for the installation of PV systems with or without storage for self-consumption with the application of energy offsetting. Subsidies for households range from 45% to 75% of the total cost depending on their income. In total, 45 million € was earmarked for vulnerable households while citizens with an annual income of up to 20,000 € or families with an income of up to 40,000 € are entitled to an overall 100 million €.

According to the provisions of the revised NECP the existing funding programmes to improve the energy efficiency of residential buildings will continue, while they will aim to support energy-poor households.

The following policies and measures are foreseen in the revised NECP related to the residential buildings:

- M6: Financial programs for the renovation of the residential buildings - Economic measure.
- M8: Adoption of fiscal and urban planning incentives for the implementation of energy-saving interventions in buildings of the residential and tertiary sectors - Regulatory and economic measure.

- M9: Promotion of RES systems to satisfy the heating and cooling needs in the building sector - Regulatory and economic measure.
- M10: Replacement of old and energy-consuming electrical appliances with energy-efficient ones - Economic measure.
- M11: Regulatory measures to promote nearly zero consumption buildings - Regulatory measure.
- M12: Regulatory, fiscal and financial incentives for the promotion of buildings above the minimum energy requirements - Regulatory and economic measure.
- M14: Strengthening the role and improving the regulatory framework of energy efficiency obligation scheme - Regulatory measure.
- M15: Application of energy efficiency auctions - Economic measure
- M16: Development of the regulatory framework for on-bill financing - Regulatory measure.
- M20: Development of a qualification, accreditation and certification scheme for the energy efficiency professionals - Regulatory measure.
- M21: Reinforcement of the role of Energy Performance Certificates - Regulatory measure.
- M22: Conduction of information and awareness-raising activities - Information-awareness raising measure.
- M25: Promotion of climate-neutral cities using ICT technologies – Technical and economic measure.
- M30: Revision of the Action Plan for the Confrontation of Energy Poverty and implementation of foreseen policy measures - Regulatory, economics and information-awareness raising measures.

Furthermore, nine policy measures have been integrated into the Action Plan for the Confrontation of Energy Poverty to fulfil the specified targets. The proposed policy measures have been classified into the following three categories:

I. Measures for the short-term protection of energy-poor households
   - M1: Improvement of the Social Tariff
   - M2: Provision of energy cards to energy-poor households
   - M3: Regulatory measures for the protection of energy-poor households

II. Measures for the energy upgrade of the energy-poor households' buildings and the promotion of RES
   - M4: Energy upgrade of the energy-poor households' building including the installation of RES systems
   - M5: Provision of incentives to energy-poor households within the framework of the Just Transition Plan
   - M6: Provision of incentives to energy-poor households within the framework of the EEOs
   - M7: Provision of incentives to energy-poor households within the framework of Energy Communities

III. Information and awareness-raising measures

- M8: Conduction of information and awareness-raising measures within the framework of the EEOs
- M9: Conduction of information and awareness-raising measures implemented centrally at the national level

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 other) 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 residential buildings in Greece. 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. Moreover, the current deviations in 2021 and 2022 from achieving the building renovation target will lead to the initiation of additional policy measures. The current programme for the renovation of the residential buildings (Exoikonomo programme) 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 self-consumption through the conduction of targeted policies and measures will mobilize 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 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 Greek economy (e.g., increased GVA, and 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 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 minimizing 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. Furthermore, the Action Plan for the alleviation of energy poverty will lead to the massive energy renovation of the buildings that dwell energy poor households combating energy poverty on a long-term basis. 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 15 presents the factors that affect the preparation of the building renovation roadmap.

Table 17. Identification and assessment of the factors, which affect the building renovation roadmap.

	External factors to consider	Factors affect building renovation roadmaps	Importance to the renovation roadmap (High-medium-low)
Political	***Policy goals/specified national targets (e.g., in energy, environment, regional development)***	Specification of building renovation target within the NECP at the national level for 2030 (60 thousand buildings annually)	High
		Adoption of the long-term strategy for the renovation of the building stock	High
		Deviations in 2021 and 2022 from achieving the building renovation target of 2030	High
	Incentives/financial Measures	Implementation of a continuous programme for the renovation of the residential buildings (Exoikonomo programme) since 2011	High
		Centrally designed and implemented building renovation policies and measures	High
		Promotion of PV systems in buildings for self-consumption through targeted policies and measures	High
		Need to improve and simplify the existing programme for the renovation of the residential buildings (Exoikonomo programme) to become more effective	High
	EU directives focused on 2050 Governance structures (e.g.,	Establishment of NECP committee and the working group for monitoring the progress of	Medium

	External factors to consider	Factors affect building renovation roadmaps	Importance to the renovation roadmap (High-medium-low)
	formal or non-formal structures that support governance	the implemented policies and measures	
		Difficulties in monitoring the progress of the implemented policies and measures aiming at the building renovation	Medium
	Pending legislation changes	Harmonization of the national legislation with Fit-for-55 packages leading to the adoption of more ambitious energy and climate change targets	High
	Political stability and remuneration framework	Lack of coordination among the authorities at the different administrative levels	Medium
		Political stability ensuring a robust and consistent vision for the renovation of buildings	Medium
Economic	***Availability of lending funds***	Satisfactory availability of lending funds for the banking sector	High
		Strict requirements for providing lending funds to households	High
		Limited understanding of the energy efficiency interventions increasing the perceived risk	Medium
	Capacity of construction and energy sector	Partial ability of the construction sector to satisfy the demand for the renovation of the buildings	Medium
	Competitiveness	Urgent need to improve the existing levels of competitiveness within the Greek economy	Low
	Cost of living	Considerable increase in the cost of living due to the energy crisis	High
		High inflation increasing the cost of living	High
	Demand for building renovation and energy services	Increased interest in renovating the buildings to address the impacts triggered by the energy crisis	High
	Economic development patterns (future trend)	Fluctuations are expected in the next years	High
	Economic growth/decline (current status)	Lack of stability. Temporary economic growth after the economic recession and economic decline afterwards due to COVID-19 and the war in Ukraine	High
	Energy expenses	High energy expenses for all end-users due to the energy crisis	High
	Energy prices	High energy prices	High
	Energy services companies	Limited activation of energy services companies	Low
	Energy taxation	Increased levels of energy taxation considerably higher than the minimum, which are foreseen by the respective legislation	High
	Interest rates	High interest rates increasing the lending cost	High
	Prevailing economic sectors	Meaningful contribution of the construction	High

	External factors to consider	Factors affect building renovation roadmaps	Importance to the renovation roadmap (High-medium-low)
	in terms of GVA with competitive advantages	sector to the Greek economy	
	Skilled energy efficiency professionals	Need to enhance the existing skills of the energy efficient	Medium
	Split incentives	No targeted incentives for addressing the split incentives problem	Medium
	Unemployment	Urgent need to reduce unemployment	High
	Financing renovation interventions	Difficulty for households to provide their own funds for implementing the required renovation interventions	High
		Limited access to loans	High
Social	***Energy consumption & production patterns***	Continuous reduction of energy consumption mainly due to external factors, such as economic recession, energy crisis	High
	Level of awareness on delivered impacts by RES and energy efficiency	Low level of awareness for all end-users	High
	Social capacity	Low social capacity despite the increasing number of energy communities	Low
	Institutional capacity	Low institutional capacity	Low
	Lifestyle factors	Tendency to adopt a more energy-intensive lifestyle	Medium
	Demographics	Continuous reduction of the population	Medium
		Continuous ageing of the population	Medium
	Rates and characteristics of energy poverty in the population	Increase in energy poverty due to the high energy prices	High
	Rates and characteristics of general poverty in the population	Increase in general poverty due to the increase in the inflation and the high energy prices	High
	Tenancy	Increased evictions due to the increase in rents	Medium
	Resistance to change	Improvement of the willingness to accept changes	Low
	Willingness to accept the implementation of energy efficiency interventions	Annoyance from the implementation of energy efficiency interventions in the neighbouring buildings	Medium
	Role of prosumers	Increased understanding and acceptance of prosumerism and community-based energy	High
Technology	***Automation***	No targeted framework for promoting automation	Low
	Innovation	No targeted framework for promoting innovation	Low
	Disruptive technologies	No targeted framework for promoting disruptive technologies	Low
	Social networking	Increasing experience in social networking	Medium
	Smart city concept	Lack of smart city platforms	Medium

	External factors to consider	Factors affect building renovation roadmaps	Importance to the renovation roadmap (High-medium-low)
		Promotion of smart cities within the carbon-neutral cities concept	Medium
	New energy-saving technologies	Limited penetration of new innovative energy-saving technologies	Medium
	Renewables technologies	High penetration of RES technologies	High
	Degree of digitalization of the energy sector	Low digitalization of the energy sector	High
	Smart meters deployment	Low deployment of smart meters	High
Environment	***Environmental restrictions imposed by in-country***	Limited environmental restrictions during the implementation of renovation activities	High
	Adaptation policies	Limited knowledge of adapting buildings to climate change	High
	Sustainable energy resources/potential	High energy saving and RES potential	High
		Low efficiency of the existing building stock	High
	Circular economy	First initiatives for circular economy at the national level during the renovation of the buildings	Low
	CSR (Corporate social responsibility)	Increasing interest in CSR activities from enterprises	Low
	Ethical sourcing	Increasing visibility and responsibility for each phase of the supply chain	Low
	Future crisis	Low resistance and preparedness towards future pandemics and energy crisis	High
Legal	***Common law***	Revision of national laws to be harmonized with the sustainable goals and the energy and climate targets	High
	Legislative and regulatory framework (e.g., for energy, spatial planning, environment, regional development)	Adoption of the required legislative and regulatory framework for all energy-related issues	High
		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
		Adoption and implementation of the Action Plan for the alleviation of energy poverty for initiating the energy renovation of the buildings that dwell energy poor households	High
		Inability of the tenancy law to address the split incentives dilemma	Medium
		Address the problems that are created by the general assembly hindering the implementation of energy efficiency interventions in multi-apartment buildings	Medium
	Level of compliance with the laws	Need for updating, simplifying and optimizing the legislative and regulatory framework according to NECP	High
	Laws & regulations on	Adoption of the required laws and	High

	External factors to consider	Factors affect building renovation roadmaps	Importance to the renovation roadmap (High-medium-low)
	permissions and licenses	regulations on permissions and licenses	

6 Roadmap

6.1 Methodological approach

The building renovation roadmap for tenants dwelling in the Athens Urban area resulted by the implementation of a methodological approach, which consisted of four different steps (Figure 42).

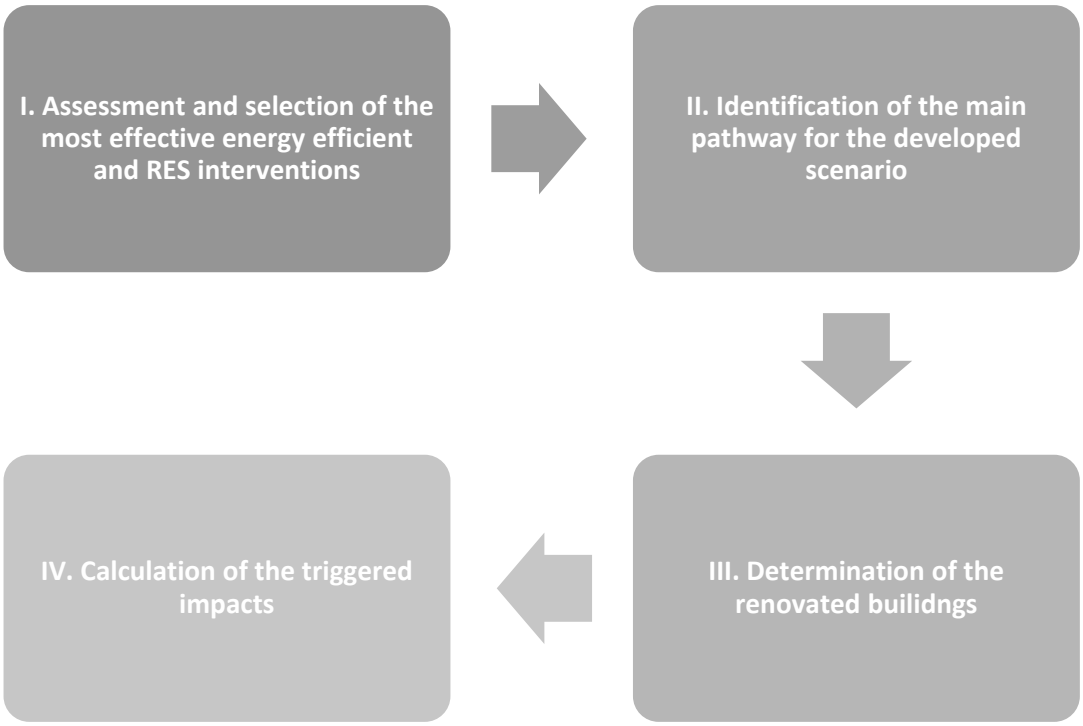

Figure 42. Applied methodological approach.

Firstly, the assessment and selection of the available energy efficient and RES interventions occurred in Step I for the case of multi-family and single-family houses, which are dwelled by tenants. 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 targeted 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

Three different combinations of energy efficiency and RES interventions were examined both for the multi-family and the single-family buildings, which are dwelled by tenants as depicted in Figure 43.

More specifically, the following renovation options were modelled and analysed:

- Option 1: Installation of aerothermal heat pump
- Option 2: Insulation of the building envelope and installation of heat pump
- Option 3: Insulation of the building envelope including windows and installation of heat pumps and solar thermal system

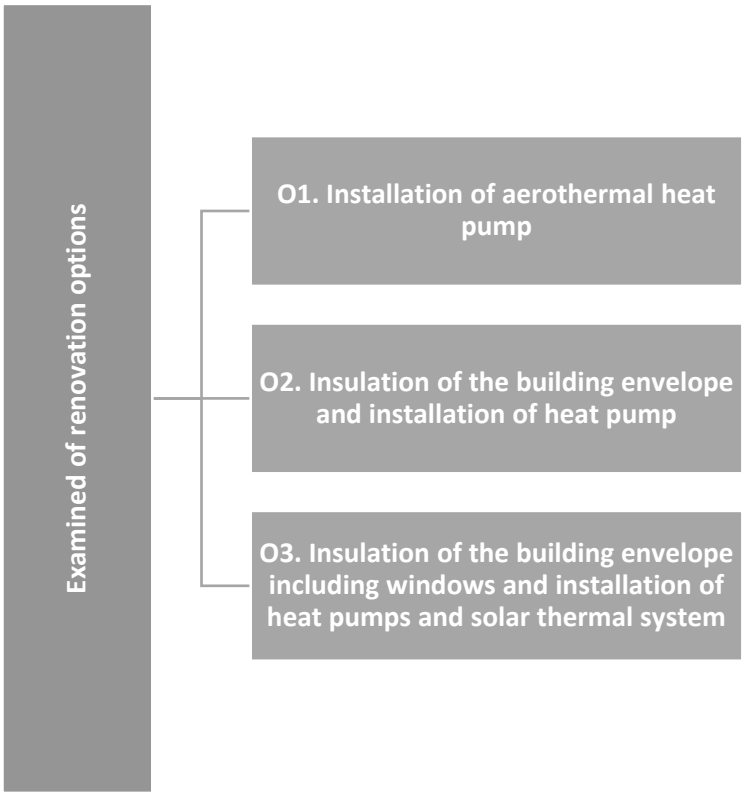

Figure 43. Examined combinations of energy efficient and RES interventions.

The analysis led to the following results as presented in Table 16 regarding the calculation of two different indicators for their comparative analysis.

Table 18. Results of the examined energy efficiency and RES interventions.

Cost-effectiveness based on the final energy savings (€/kWh)	Multi-family buildings	Single-family buildings
O1. Installation of aerothermal heat pump	0.855	0.245
O2. Insulation of the building envelope and installation of heat pump	1.847	1.100
O3. Insulation of the building envelope including windows and installation of heat pumps and solar thermal system	2.678	1.540
Cost-effectiveness based on the CO_2 emission reduction (€/kg CO_2)	**Multi-family buildings**	**Single-family buildings**
O1. Installation of aerothermal heat pump	5.434	1.453
O2. Insulation of the building envelope and installation of heat pump	7.832	4.524
O3. Insulation of the building envelope including windows and installation of heat pumps and solar thermal system	9.787	5.712

The installation of an aerothermal heat pump has the best performance on the examined indicators. Nevertheless, the combination of interventions in the building envelope with heat pumps and solar thermal systems has also an acceptable performance constituting a meaningful option for the case of the deep renovation of the building stock.

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

The main aim of the building renovation roadmap is to accelerate the deep renovation of the residential buildings, which are dwelled by tenants, 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.

Therefore, all the buildings, which have been constructed before 2005, should be renovated starting with the worst-performing buildings (the oldest ones) and continuing with the remaining ones.

The unit results of the selected combination of energy efficient and RES interventions (interventions in the building envelope and installation of heat pumps and solar thermal systems) are presented in Table 17.

Table 19. Estimated unit results for the selected energy efficiency and RES interventions.

Selected energy efficiency and RES interventions	Multi-family buildings	Single-family buildings
Final energy savings annually (kWh)	41,335	29,454
Primary energy savings annually (kWh)	53,832	36,647
CO_2 emission reduction annually (kg CO_2)	11,309	7,941
Investment cost (€)	110,686	45,358
Cost savings annually (€)	5,324	3,760

6.4 Step III: Determination of the renovated buildings totally

The number of renovated buildings was estimated taking into consideration that 15% of the households are affected by the phenomenon of energy poverty as resulted in the presented analysis within Chapter 2. Moreover, it was assumed that for households dwelling in multi-family buildings, 21% of the energy-poor households rent their residences according to data obtained by the Action Plan for the alleviation of energy poverty.

It should be noted that the buildings constructed until 2005, as presented in Table 7, have been considered for the determination of the targeted buildings.

Information about the number of newly and cumulative renovated buildings is provided in Tables 18 (for the different examined periods) and 19 (cumulative) correspondingly, including the respective trajectory and timeline.

The simultaneous implementation of the foreseen energy efficiency and RES interventions is recommended. In contrast, the insulation of the building envelope should be prioritized, 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 can be done irrespective of the foreseen interventions for the coverage of the heating and cooling needs.

Table 20. Number of newly renovated buildings for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	8,935	8,935	8,935	8,935	8,935
Energy-poor households Tenants – Single-family houses (SFH)	1,346	1,346	1,346	1,346	1,346
Total	**10,281**	**10,281**	**10,281**	**10,281**	**10,281**

Table 21. Number of cumulatively renovated buildings for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	8,935	17,871	26,806	35,742	44,677
Energy-poor households Tenants – Single-family houses (SFH)	1,346	2,691	4,037	5,382	6,728
Total	**10,281**	**20,562**	**30,843**	**41,124**	**51,405**

The estimation of the triggered impacts by the energy efficiency and RES interventions was implemented with the utilization of unitary metrics as resulted by the modelling activity, which was carried out for each examined measure within the framework of Step I (Table 17).

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 20-22 respectively. The calculation of the delivered impacts was performed using the unit results in Table 17 and the cumulative number of the renovated buildings in Table 19 for each examined period.

Table 22. Resulted cumulative final energy savings (GWh) for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	92	185	277	369	462
Energy-poor households Tenants – Single-family houses (SFH)	40	79	119	159	198
Total	**132**	**264**	**396**	**528**	**660**

Table 23. Resulted cumulative primary energy savings (GWh) for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	120	241	361	481	601
Energy-poor households Tenants – Single-family houses (SFH)	49	99	148	197	247
Total	**170**	**339**	**509**	**678**	**848**

Table 24. Resulted cumulative CO_2 reduction (ktn CO_2) for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	25	51	76	101	126
Energy-poor households Tenants – Single-family houses (SFH)	11	21	32	43	53
Total	**36**	**72**	**108**	**144**	**180**

The expected employment impacts (Table 23) were calculated 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 25. Resulted employment impacts (person-years) for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	3,828.5	3,828.5	3,828.5	3,828.5	3,828.5
Energy-poor households Tenants – Single-family houses (SFH)	945.5	945.5	945.5	945.5	945.5
Total	**4,774.0**	**4,774.0**	**4,774.0**	**4,774.0**	**4,774.0**

Finally, the expected cumulative multiple benefits were calculated (Table 24) assuming that they are equal to 0.039 €/kWh of final energy savings (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 26. Resulted cumulative multiple benefits (million €) for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses- Apartments (MFB)	4	7	11	14	18
Energy-poor households Tenants – Single-family houses (SFH)	2	3	5	6	8
Total	**5**	**10**	**15**	**21**	**26**

7 Policies and measures

The specified renovation targets will be achieved with the design and implementation of 11 policies and measures. It should be mentioned that the described policies and measures are in full alignment with the provisions of the NECP. The tailor-made design of the described policies and measures should occur taking into consideration the characteristics of the energy-poor households. Indicatively, it is mentioned that the subsidy rates can be considerably higher for the case of energy-poor households covering the investment gap and their inability to provide their own funds for the materialization of the investments.

Information about the required policies and measures is provided in the following tables.

Name of policy or measure	**M1: Fostering the construction and energy renovation of buildings exceeding minimum energy requirements**
Short description	**M1** will foster the conduction of energy efficiency interventions by providing incentives to exceed energy requirements beyond the minimum ones through the initiation of regulatory measures (such as the increase of the allowed building area with higher energy performance than the minimum ones and the obligation to examine at the stage of preparing a building permit design the use of high-efficiency alternative energy and heat supply systems) and additional fiscal and financial measures. The construction of passive buildings will be supported, while the installation of photovoltaic systems for the on-site production of electricity will be boosted. Targeted pilot projects will be designed to ensure the readiness of the involved professionals and the participation of energy-poor households. Finally, targeted incentives will be designed for the households that dwell in multi-family buildings in the case that all of them participate in the measure.
Quantified objective	Renovation of the residential buildings
Type of policy or measure	Regulatory and economic measure
Planned budget and funding sources	Public and private funds
Entities responsible for implementing the policy	Ministry of Environment and Energy Ministry of Economy and Finance
Number of affected households	Contribution to the expected impacts triggered by M3
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Existing
Date of entry into force	2025
Implementation period	2025-2050

Name of policy or measure	M2: Enhancing the role of the energy performance certificates
Short description	**M2** foresees the reinforcement of the role of energy performance certificates of buildings, while they will be accompanied by the renovation passports providing recommendations for the most cost-effective energy rehabilitation measures. The renovation passports will describe a sequence of renovation steps to transform the building into a zero-emission building, estimate the expected benefits in terms of energy savings, savings on energy bills and operational greenhouse emission reductions as well as wider benefits related to health and comfort and the improved adaptive capacity of the building to climate change and contain information about potential financial and technical support. Moreover, the framework of the renovation passports will be expanded to cover also relevant aspects of the phenomenon of energy poverty. Finally, the existing system for the permanent monitoring and control of the energy performance of building certificates will be improved covering also the issued renovation passports.
Quantified objective	Awareness-raising for issues related to the building renovation
Type of policy or measure	Regulatory measure
Planned budget and funding sources	Public funds
Entities responsible for implementing the policy	Ministry of Environment and Energy
Number of affected households	51,405 houses dwelled by tenants
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Planned
Date of entry into force	2025
Implementation period	2025-2026

Name of policy or measure	M3: Overcoming split incentive barrier
Short description	**M3** will remove the potential regulatory and non-regulatory barriers to energy efficiency, without prejudice to the basic principles of the property and tenancy law regarding the split of incentives between the owner and the tenant of a building or among owners. Targeted measures will be initiated to ensure that the involved parties will not be deterred from making efficiency-improving investments that they would otherwise have made due to the fact that they will not

Name of policy or measure	M3: Overcoming split incentive barrier
	individually obtain the full benefits or by the absence of rules for dividing the costs and benefits between them. The launched measures may include indicatively, the simplification of the decision-making processes in multi-owner properties, the provision of incentives both to energy-poor owners and tenants, the repeal or amendment of legal or regulatory provisions, the adoption of guidelines and interpretative communications and the simplification of the required administrative procedures.
Quantified objective	Renovation of the private-rented residential buildings
Type of policy or measure	Regulatory and economic measure
Planned budget and funding sources	Public and private funds
Entities responsible for implementing the policy	Ministry of Environment and Energy Ministry of Economy and Finance
Number of affected households	51,405 houses dwelled by tenants
Expected impact in relation to the specified targets	Final energy savings: 660 GWh Primary energy savings: 848 GWh CO_2 emission reduction: 180 ktn
Status of implementation	Planned
Date of entry into force	2025
Implementation period	2025-2050

Name of policy or measure	M4: Fostering the self-consumption of the produced electricity
Short description	**M4** will support renewables self-consumers for the installation mainly of photovoltaic systems with the initiation of a dedicated support scheme including the provision of financial and fiscal incentives. The design of the support scheme for the case of energy-poor households should be carried out taking into account the triggered benefits due to the deployment of decentralized renewable energy systems and the increase of prosumerism. The subsidy rate should be decided to increase potentially the private leverage taking into consideration the actual capability of the involved end-users to provide their own funds with an objective and transparent approach. Moreover, non-discriminatory and proportionate charges and fees will be applied to renewable self-consumers, while transparent and fair allocation rules will be specified in the case that the renewable self-consumers are located in the same building. Finally, an analysis will occur to identify potential barriers, while specific

Name of policy or measure	M4: Fostering the self-consumption of the produced electricity
	policies and measures will be initiated to address them in the case that their existence will be justified ensuring simultaneously that renewables self-consumers contribute in an adequate and balanced way to the overall cost-sharing of the system when electricity is fed into the grid.
Quantified objective	Renovation of the residential buildings
Type of policy or measure	Regulatory and economic measure
Planned budget and funding sources	Public and private funds
Entities responsible for implementing the policy	Ministry of Environment and Energy Ministry of Economy and Finance HEDNO SA
Number of affected households	Contribution to the expected impacts triggered by M3
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Existing
Date of entry into force	2025
Implementation period	2025-2050

Name of policy or measure	M5: Supporting the renewable and the citizen energy communities
Short description	**M5** will strengthen the role and operation of both the renewable energy communities and the citizen energy communities for the alleviation of energy poverty through the design and implementation of specialized financial instruments. Specifically, dedicated fiscal and economic incentives will be provided to foster both the further deployment of renewable energy sources and the materialization of energy efficiency projects in residential buildings through the application of new business models.
Quantified objective	Renovation of the residential buildings
Type of policy or measure	Economic measure
Planned budget and funding sources	Public and private funds
Entities responsible for implementing the policy	Ministry of Environment and Energy Ministry of Economy and Finance
Number of affected households	Contribution to the expected impacts triggered by M3
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Planned
Date of entry into force	2025

Name of policy or measure	M5: Supporting the renewable and the citizen energy communities
Implementation period	2025-2050

Name of policy or measure	M6: Organizing information and training activities
Short description	**M6** will promote the conduction of awareness-raising and dissemination activities in all final energy consumption sectors with a focus on energy-poor households. Specialized awareness-raising and dissemination activities will be organized both for the energy-poor households and the involved engineers taking into account the peculiarities of the energy poverty phenomenon. Moreover, the development of databases with information about the building stock and the implemented energy efficiency interventions and voluntary certification schemes of ecological, green and sustainable buildings can improve the current level of knowledge and awareness. Finally, the concept of carbon footprint and the impact of energy efficiency measures throughout the entire life cycle of the promoted technologies and equipment should be promoted to familiarize the involved stakeholders with the full impact of energy efficiency.
Quantified objective	Awareness-raising for issues related to the building renovation
Type of policy or measure	Awareness-raising measure
Planned budget and funding sources	Public funds
Entities responsible for implementing the policy	Ministry of Environment and Energy
Number of affected households	51,405 houses dwelled by tenants
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Planned
Date of entry into force	2025
Implementation period	2025-2027

Name of policy or measure	M7: Establishing one-stop shops
Short description	**M7** will aim at the establishment of one-stop shops to support energy-poor households with tailor-made information, advice and financing during the renovation of their buildings. Different business models will be utilised according to the INNOVATE project providing different services such as indicatively:

Name of policy or measure	M7: Establishing one-stop shops
	• Facilitation model: (e.g. reinforce awareness about energy renovation benefits, inform about the optimal renovation works, advice for the different steps etc). • Coordination model: (e.g. undertake the coordination of the involved market actors without having responsibility for the outcomes of the renovation nor supporting them in all renovation steps). • All-inclusive model: (e.g. provide full renovation packages undertaking the responsibility for the expected outcomes and supporting them to all renovation steps). • ESCO-type model: (e.g. provide full renovation packages with guaranteed energy savings undertaking the responsibility for the expected outcomes and supporting them to all renovation steps). The one-stop shops will facilitate also the provision of financing through different options such as the provision of products negotiated with partner technology suppliers and service providers, the development of local incentive schemes and the provision of their own financial products.
Quantified objective	Awareness-raising for issues related to the building renovation and provision of technical assistance
Type of policy or measure	Awareness-raising measure
Planned budget and funding sources	Public funds
Entities responsible for implementing the policy	Ministry of Environment and Energy Municipalities
Number of affected households	51,405 houses dwelled by tenants
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Planned
Date of entry into force	2025
Implementation period	2025-2027

Name of policy or measure	M8: Developing a scheme for the qualification, accreditation and certification of energy efficiency professionals
Short description	**M8** will aim at the improvement of the existing and, if necessary, the establishment of new qualification, accreditation, or certification schemes for all energy efficiency professionals (e.g. providers of energy services, energy advisors, energy managers, responsible engineers of the energy efficiency of buildings and installers of energy-related building elements that are related to the

Name of policy or measure	M8: Developing a scheme for the qualification, accreditation and certification of energy efficiency professionals
	improvement of the energy performance of a building, developers of design and technical documentation). Specialized training programs will be organized, tools will be developed and technical support will be provided within the framework of the current measure taking into account the peculiarities of the energy poverty phenomenon. It should be noted that the measure will focus also on the RES professionals. Finally, it will examine the expansion of the measure to cover the accreditation and certification of energy-efficiency equipment and technologies.
Quantified objective	Awareness-raising for issues related to the building renovation
Type of policy or measure	Regulatory and awareness-raising measures
Planned budget and funding sources	Public funds
Entities responsible for implementing the policy	Ministry of Environment and Energy
Number of affected households	51,405 houses dwelled by tenants
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Planned
Date of entry into force	2025
Implementation period	2025-2050

Name of policy or measure	M9: Promoting energy audits in households
Short description	**M9** will support financially the conduction of energy audits. More specifically, a pilot program will be launched for the case of energy-poor households covering the implementation cost to increase their awareness and to promote their further conduction according to the provisions of the EED. Emphasis will be given on improving the understanding and existing level of knowledge of the targeted households about the energy poverty phenomenon. Furthermore, the derived recommendations can be supported through the provision of financial aid.
Quantified objective	Awareness-raising for issues related to the building renovation
Type of policy or measure	Awareness-raising measure
Planned budget and funding sources	Public funds
Entities responsible for	Ministry of Environment and Energy

Name of policy or measure	M9: Promoting energy audits in households
implementing the policy	
Number of affected households	2,500 houses dwelled by tenants
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Planned
Date of entry into force	2025
Implementation period	2025-2027

Name of policy or measure	M10: Strengthening the technical and administrative capacity of the involved policymakers
Short description	**M10** will reinforce on a continuous basis the technical and administrative capacity of the involved policymakers to facilitate the effective design, implementation, monitoring and evaluation of the energy efficiency measures, which will facilitate the alleviation of energy poverty. Specialized trainings will be organized and sophisticated tools and materials will be prepared to ensure that the existing level of knowledge and the required skills are sufficient. Training can include requirements for the preparation of project/technical documentation to increase the quality and the utilization of the projects for the deep renovation of the buildings, but also the preparation of technical documentation and design brief for their implementation according to the peculiarities of the energy poverty phenomenon. Finally, tools will be further improved and, when needed, developed for monitoring the achievement of the established targets and the performance of the implemented policies and measures.
Quantified objective	Awareness-raising for issues related to the building renovation
Type of policy or measure	Awareness-raising measure
Planned budget and funding sources	Public funds
Entities responsible for implementing the policy	Ministry of Environment and Energy
Number of affected households	51,405 houses dwelled by tenants
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
Status of implementation	Planned
Date of entry into force	2025
Implementation period	2025-2027

Name of policy or measure	M11: Fostering the implementation of innovative financing mechanisms
Short description	**M11** will foster the implementation of innovative financing mechanisms, which will facilitate the implementation of the renovation roadmap for combating energy poverty. Firstly, the main challenges, which are derived by the design and implementation of the envisaged financial measures for energy-poor households, will be addressed such as the maximization of the expected leverage, the most cost-effective exploitation of the available fund, the adoption of innovative financing tools and the active mobilization of the domestic financial sector. All the available funds will be mobilized at national and EU levels. The effective coordination of the available financial stream is essential for the effective implementation of the planned financial measures. Moreover, the provision of technical assistance will be foreseen for facilitating the financing of energy efficiency projects. Moreover, the bankability of the energy efficiency projects will be improved with the utilization of specialized tools and methodologies to minimize the existing levels of risk. The implementation of a quality assurance scheme and the establishment of a methodological approach for the standardization of the different steps during the evaluation of energy efficiency projects will facilitate the de-risking of energy efficiency investments. The involvement of the banking sector is essential, while the design of new financial products specifically dedicated to the financing of energy efficiency projects will facilitate the financing of the energy efficiency projects. Towards this direction, specialized training will be organised to achieve the above-mentioned objectives. Finally, the foreseen market-based instruments will be utilised to accelerate the renovation investments in the residential buildings. More specifically, the obligated parties within the framework of the Energy Efficiency Obligation Scheme will be incentivised to focus on households, while the adoption of the legislative framework for on-bill financing will provide an alternative option for repaying the foreseen investments.
Quantified objective	Awareness-raising for issues related to the building renovation
Type of policy or measure	Regulatory and awareness-raising measures
Planned budget and funding sources	Public funds
Entities responsible for	Ministry of Environment and Energy

Name of policy or measure	M11: Fostering the implementation of innovative financing mechanisms
implementing the policy	Ministry of Economy and Finance
Number of affected households	51,405 houses dwelled by tenants
Expected impact in relation to the specified targets	Contribution to the expected impacts triggered by M3
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 25 (for the examined periods) and 26 (cumulatively) both for the case of the new and cumulative ones.

Table 27. Required new investments (million €) for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	247	247	247	247	247
Energy-poor households Tenants – Single-family houses (SFH)	61	61	61	61	61
Total	**308**	**308**	**308**	**308**	**308**

Table 28. Required cumulative investments (million €) for the examined periods.

Roadmap	2025-2030	2031-2035	2036-2040	2041-2045	2046-2050
Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	247	495	742	989	1,236
Energy-poor households Tenants – Single-family houses (SFH)	61	122	183	244	305
Total	**308**	**617**	**925**	**1,233**	**1,541**

The allocation of the total investments to the different energy efficiency and RES interventions is displayed in Figure 44.

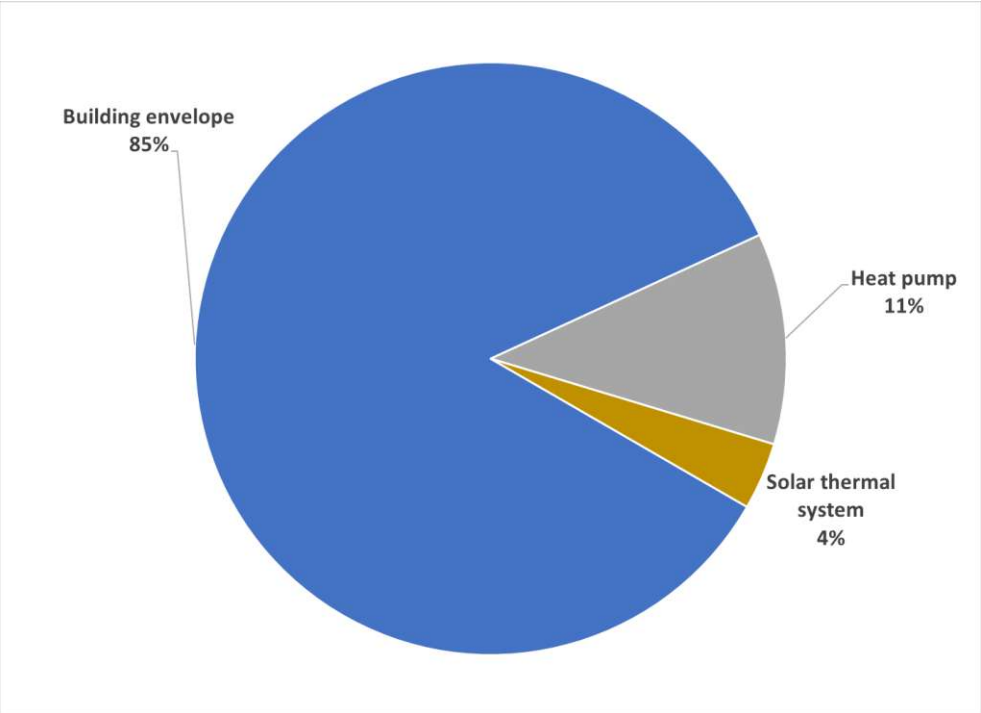

Figure 44. Allocation of the total investments to the different energy efficiency and RES interventions for the case of multi-family and single-family houses dwelled by tenants.

The allocation of the total investments to public and private investments is presented in Table 27.

The allocation was performed assuming that the energy-poor households can be divided into three different categories with different capabilities to contribute with their own funds to the planned investments. More specifically, the following assumptions were made:

- Category I: 20% of the targeted energy-poor households will receive public aid equal to 50% of the foreseen investment cost.
- Category II: 30% of the targeted energy-poor households will receive public aid equal to 75% of the foreseen investment cost.
- Category III: 50% of the targeted households will receive public aid equal to 90% of the foreseen investment cost.

Table 29. Allocation of the total investments to public and private investments (million €) for the examined periods.

Period	Roadmap	Energy poor households	Share	Public funds	Private (own) funds	Total
2025-2030	Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	Category I	20%	25	25	49
		Category II	30%	56	19	74
		Category III	50%	111	12	124
		Total	**100%**	**191**	**56**	**247**
	Energy-poor households Tenants – Single-family houses (SFH)	Category I	20%	6	6	12
		Category II	30%	14	5	18
		Category III	50%	27	3	31
		Total	**100%**	**47**	**14**	**61**
2031-2035	Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	Category I	20%	25	25	49
		Category II	30%	56	19	74
		Category III	50%	111	12	124
		Total	**100%**	**191**	**56**	**247**
	Energy-poor households Tenants – Single-family houses (SFH)	Category I	20%	6	6	12
		Category II	30%	14	5	18
		Category III	50%	27	3	31
		Total	**100%**	**47**	**14**	**61**
2036-2040	Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	Category I	20%	25	25	49
		Category II	30%	56	19	74
		Category III	50%	111	12	124
		Total	**100%**	**191**	**56**	**247**
	Energy-poor households Tenants – Single-family houses (SFH)	Category I	20%	6	6	12
		Category II	30%	14	5	18
		Category III	50%	27	3	31
		Total	**100%**	**47**	**14**	**61**
2041-2045	Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	Category I	20%	25	25	49
		Category II	30%	56	19	74
		Category III	50%	111	12	124
		Total	**100%**	**191**	**56**	**247**

Period	Roadmap	Energy poor households	Share	Public funds	Private (own) funds	Total
	Energy-poor households Tenants – Single-family houses (SFH)	**Category I**	20%	6	6	12
		Category II	30%	14	5	18
		Category III	50%	27	3	31
		Total	**100%**	**47**	**14**	**61**
2046-2050	**Energy-poor households Tenants – Multi-family houses- Apartments (MFB)**	**Category I**	20%	25	25	49
		Category II	30%	56	19	74
		Category III	50%	111	12	124
		Total	**100%**	**191**	**56**	**247**
	Energy-poor households Tenants – Single-family houses (SFH)	**Category I**	20%	6	6	12
		Category II	30%	14	5	18
		Category III	50%	27	3	31
		Total	**100%**	**47**	**14**	**61**
2025-2050	**Energy-poor households Tenants – Multi-family houses- Apartments (MFB)**	**Category I**	20%	124	124	247
		Category II	30%	278	93	371
		Category III	50%	556	62	618
		Total	**100%**	**958**	**278**	**1236**
	Energy-poor households Tenants – Single-family houses (SFH)	**Category I**	20%	31	31	61
		Category II	30%	69	23	92
		Category III	50%	137	15	153
		Total	**100%**	**236**	**69**	**305**

It should be noted that the analysis of the different types of financing instruments has been indicated within the previous chapter for each policy and measure separately.

9 Renovations triggered by REVERTER

REVERTER is expected to contribute to the renovation of privately rented houses in the period of 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 the 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 web tool", approximately 15,700 households in the Athens Urban Area will be reached through information campaigns, home visits and social engagement events. Of these households, it is estimated that around 1,800 will visit the physical and digital one-stop shops and around 15%, i.e. 275 households, will express interest in upgrading their home in the next 5 years. The distribution of these households across the three REVERTER roadmaps was carried out proportionally, taking into account the number of houses and energy-poor households in each category (tenants in single-family and multi-family residential buildings, apartment owners in multi-family residential buildings and single-family residential building owners).

The contribution of the REVERTER project is summarised in Table 28, while the allocation of the total investments to public and private investments triggered by the REVERTER project is presented in Table 29. It should be noted that the foreseen investments are expected after the completion of REVERTER project in 2026.

Table 30. Contribution of the REVERTER project to the implementation of the specific roadmap for the renovation of privately-rented buildings in the period 2025-2030.

Impacts	Energy-poor households Tenants – Multi-family houses-Apartments (MFB)	Energy-poor households Tenants – Single-family houses (SFH)	*Total*
Number of newly renovated buildings	**53**	**8**	**61**
Resulted cumulative final energy savings (GWh)	0.55	0.24	0.78
Resulted cumulative primary energy savings (GWh)	0.71	0.29	1.00
Resulted cumulative CO_2 reduction (ktn CO_2)	0.15	0.07	0.21
Resulted employment impacts (person-years)	22.71	5.62	28.33
Resulted cumulative multiple benefits (million €)	0.02	0.01	0.04
Required new investments (million €)	**1.47**	**0.36**	**1.83**

Table 31. Allocation of the total investments to public and private investments triggered by the REVERTER project (million €) in the period 2025-2030.

Period	Roadmap	Energy poor households	Share	Public funds	Private (own) funds	Total
2025-2030	Energy-poor households Tenants – Multi-family houses- Apartments (MFB)	**Category I**	20%	0.15	0.15	0.29
		Category II	30%	0.33	0.11	0.44
		Category III	50%	0.66	0.07	0.73
		Total	**100%**	**1.14**	**0.33**	**1.47**
	Energy-poor households Tenants – Single-family houses (SFH)	**Category I**	20%	0.04	0.04	0.07
		Category II	30%	0.08	0.03	0.11
		Category III	50%	0.16	0.02	0.18
		Total	**100%**	**0.28**	**0.08**	**0.36**

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 45.

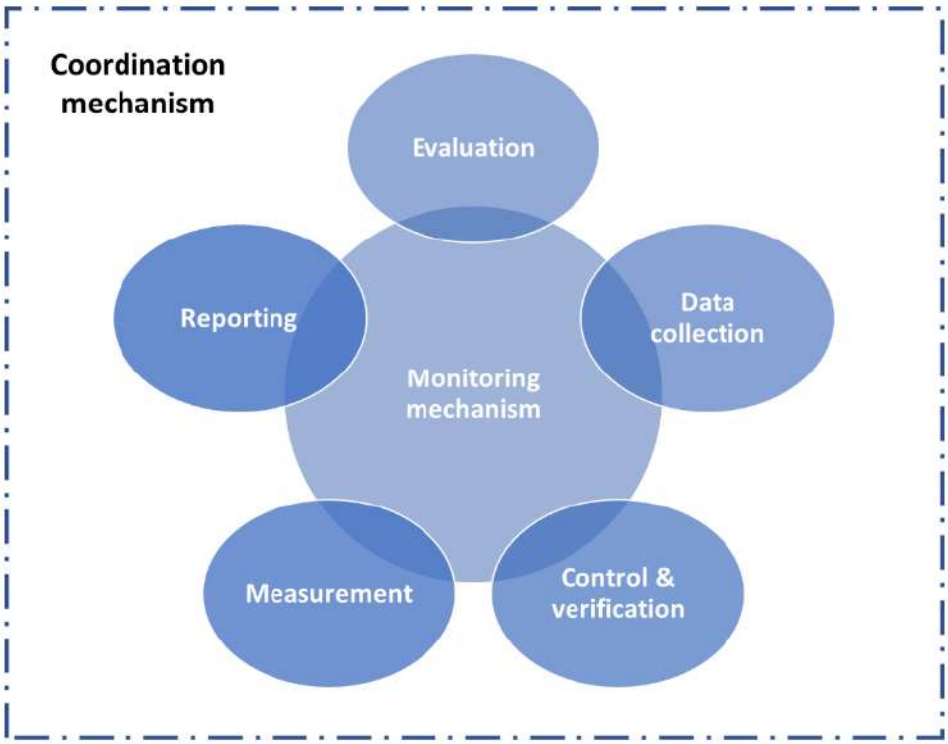

Figure 45. Overview of the sub-mechanisms within the established monitoring and evaluation framework.

The Ministry of Environment and Energy should be appointed as 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 investments. The 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. The horizontal coordination enables the effective communication and administration of the different energy efficiency measures, and schemes of programmes at the same level.

The monitoring sub-mechanism aims at the continuous monitoring of the implemented energy efficiency and RES investments and the delivered impacts 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, which is recommended to be implemented through the development and operation of an IT platform. 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. Last but not least the development of the sub-mechanism will be performed in compliance with the respective monitoring within the framework of the Action Plan for the alleviation of energy poverty.

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 should 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 on the basis of 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 in accordance with specific criteria, such as their accuracy, robustness and coherence within the control and verification sub-mechanism in Step 5. Indicative methods to validate 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 46.

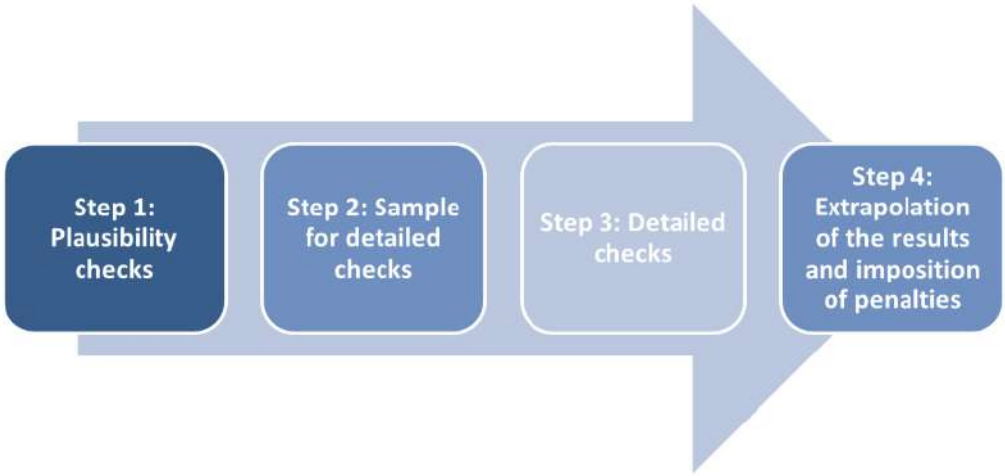

Figure 46. Steps for the conduction of the required control and verification activities.

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 following 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.

A template will be prepared for the collection of the required data including the establishment of the appropriate data collection procedures. The developed reporting template will facilitate the collection of the following information for each building category separately as the minimum required with a coherent and homogeneous approach:

- Number of renovated buildings
- Number of affected energy-poor households
- Renovation rate (%)
- Type of the implemented energy efficiency and RES interventions
- Achieved final energy savings annually (GWh)
- Achieved primary energy savings annually (GWh)
- Achieved CO_2 emission reduction annually (ktn)
- Delivered cost savings annually (million €)
- Investment cost (million €)
- Public funds both total and for each implemented policy and measure separately (million €)
- Private funds both totally and for each implemented policy and measure separately (million €)
- Number of buildings with improved comfort levels

Furthermore, the potential deviations for all the previously-mentioned information 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.

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/or cost-benefit analyses. The analysis aims to assess the effectiveness of the implemented policies and measures to decide either their continuation, or their improvement or their replacement with new more effective ones to achieve the specified renovation targets.

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.