Deep REnovation roadmaps to decrease households VulnERability to Energy poveRty

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Deliverable 3.4 - Renovation roadmaps

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About this document

This deliverable provides the methodology and the results of the analysis conducted for the preparation of the REVERTR building renovation roadmaps in the four targeted areas within the framework of Task 3.5. The renovation roadmaps were developed taking into consideration both the derived conclusions and policy recommendations resulting from the analysis of the best practices and the different characteristics and conditions of the targeted countries, which are detailed in Deliverables 2.1 and 3.2, respectively.

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Disclaimer

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Executive summary

The present deliverable describes the nine building renovation roadmaps developed for the four REVERTER pilot areas (namely Brezovo, Athens Urban Area, Riga and Coimbra, respectively) aiming to combat energy poverty by deeply renovating dwellings occupied by vulnerable households.

The roadmaps were developed considering the conclusions and policy recommendations resulting from the analysis of the best practices and the different characteristics and conditions of the targeted countries, which are detailed in Deliverables 2.1 and 3.2. Specifically, 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. Furthermore, 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), cope with split-incentive dilemmas and address various market, information and behavioural failures. Also, the most cost-effective energy efficiency and RES interventions are promoted (best-possible principle) ensuring the maximization of the various economic, energy, climate and social benefits triggered by the implementation of the required energy efficiency and RES interventions.

The roadmaps, in all four pilots, provide a pathway for the local, regional and national authorities to renovate all relevant building stock occupied by energy-poor households by 2050. The contribution of the REVERTER project in this direction is specified in a separate section in each roadmap.

Methodological approach

The REVERTR roadmaps were developed following a specialised methodology, which is described briefly below and is detailed in Section 2 of this report. The main steps and activities are:

I. Specification of the main objectives

Firstly, the analysis of the main objectives of the building renovation roadmap was carried out. The confrontation of the energy poverty through the deep renovation of the building envelope was considered as the main objective. Also, the maximisation of the various economic, energy, climate and social benefits triggered by the implementation of the required energy efficiency and RES interventions was promoted, as it is considered as a prerequisite for the achievement of the main objective of the building renovation roadmap.

II. Preparatory actions for the development of the roadmap

The preparation of the building renovation roadmaps was assisted through the implementation of various preparatory actions covering different aspects.

Legislative and policy framework

Initially, the existing legislative and policy framework, which is related directly and indirectly with the renovation of the building stock, was analysed at national, regional and local level, including the existing strategies. Moreover, the main policies and measures were described including quantitative information about their contribution to the energy upgrade of the building stock. Emphasis was given on the presentation of the main energy, environmental and climate change legislative and

policy frameworks at national level. Finally, the legislative context for combating energy poverty was analysed as well, including information both about the targets for the alleviation of energy poverty and the implemented and planned policies and measures for tackling it.

Identification of key stakeholders

The key stakeholders were mapped and identified representing different administrative and social level with completely different priorities and expectations. 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 national, regional and local level.

Analysis of the current levels and characteristics of energy poverty

A detailed analysis was conducted about the main characteristics of the energy poverty based on different energy poverty indicators. Generally, various energy poverty indicators should be developed at regional and local level facilitating the definition of the energy poor households' profile according to their beliefs, challenges, values, etc. The performed analysis led to the identification of the number of the households, which can be classified as energy poor in the targeted areas and inhabit in different types of buildings (e.g. detached houses, multi-apartment building, condominiums, rented properties etc.).

Analysis of the building stock

The existing building stock was analysed based on data retrieved by existing databases (e.g. Census data, Energy Performance Certificate databases, etc.) or in situ surveys to estimate the energy efficiency of residential buildings in the targeted regions. The performed analysis provided quantitative information for the building stock about the construction period, the climatic zone, the energy consumption and the utilised energy carriers for each end-use separately, the energy performance as outlined by the energy class of the issued energy performance certificates, etc. It should be noted that the calculated data were estimated for each building type separately, according to the type of the roadmap (e.g. single- family and multi-family buildings).

Prioritisation in the context of the "worst first" principle

The energy renovation of the worst-performing buildings was prioritised within the framework of the analysis of the building stock. Moreover, the energy-poor and inefficient hotspots were identified to enhance the context of the worst first principle and complement the analysis of the building stock. This analysis facilitated the association of the energy poverty with the characteristics of the buildings and the area under consideration (e.g. multifamily, private rented, social housing, income, etc.), in addition to the construction age, as well as with climatic data.

Identification and confrontation of the barriers

The identification of barriers was performed through the conduction of PESTEL analysis to identify the most important parameters and the main market barriers and failures (administrative, financial, technical, awareness and other) that impede the further promotion of deep renovation. Moreover, solutions were proposed to address the identified barriers, which are related to the various external macro-environmental factors (Political, Economic, Social, Technological, Environmental and Legal).

Establishment of OSSs

The establishment of One stop shops (OSSs) was considered as one of the most fundamental pillars of the building renovation roadmaps. The OSSs can overcome the classic renovation model, referred to as the "atomised model" that requires the homeowner (or the renter) to make all major decisions, keep in touch with all suppliers and partners involved, invest a lot of time and take risks.

The OSSs can offer advice, transforming a cumbersome and complex set of decision-making/actions by non-experts, and especially vulnerable people, into a single entry, customer-friendly offer. In this way, OSS can address the market fragmentation barriers on both demand and supply sides, overcoming some of the sociotechnical barriers surrounding the decision to renovate holistically.

III. Development of the REVERTER Roadmaps

The next phase involved the development of the roadmaps were resulted by the implementation of a methodological approach, based on the following four steps (Figure ES1).

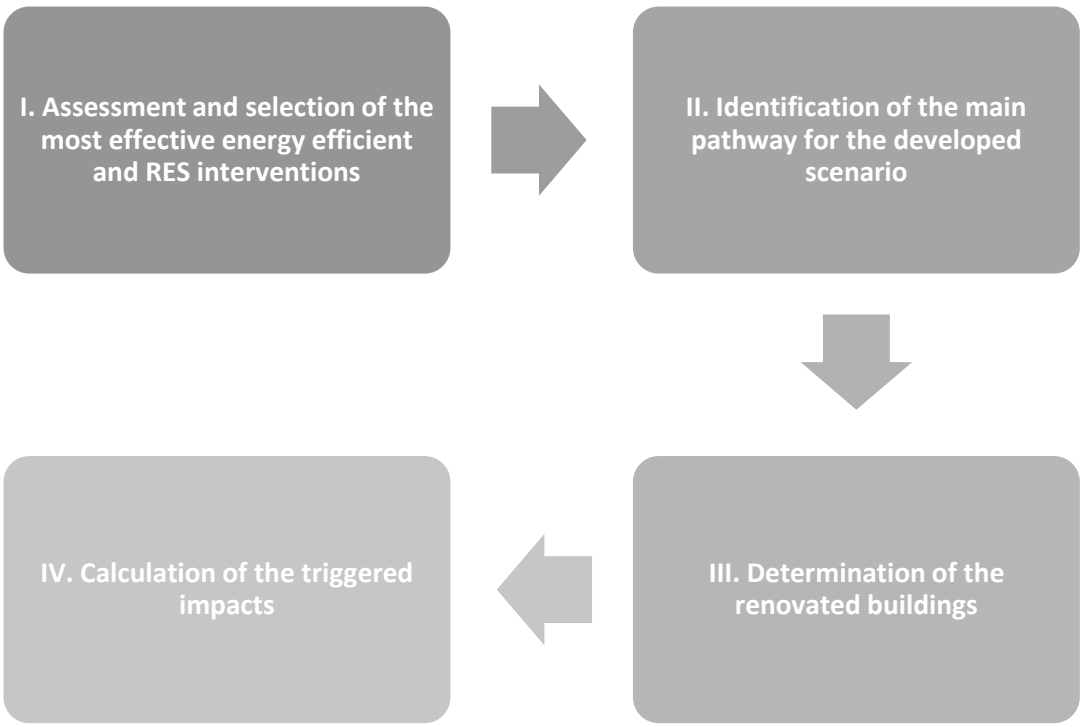

Figure ES1. Applied methodological approach.

The assessment and selection of the available energy efficient and RES interventions were carried out in Step I (Assessment and selection of the most effective energy efficient and RES interventions). It should be noted that unitary metrics (e.g. primary and final energy savings per year, investment costs, etc.) were calculated for the most effective combinations of energy efficient and RES interventions. The main pathway for combating energy poverty through for the renovation of the building stock was identified in Step II (Identification of the main pathway for the developed scenario), combining the selected energy-efficient and RES interventions within the framework of Step I with the specified renovation target and subsequently the target for the alleviation of energy poverty. Then, the number of renovated buildings was calculated for the formulated pathway in Step III (Determination of the renovated buildings), while the unitary metrics for the most effective

energy efficient and RES interventions were used for the quantification of the triggered impacts in Step IV (Calculation of the triggered impacts).

The selected building renovation roadmaps displayed the trajectory of the established targets for 2030, 2040 and 2050 including at least information about the annual energy renovation rate, the primary and final energy consumption of the building stock, the penetration of RES, the reduction of the GHG emission and the wider multiple benefits delivered by the building renovation.

IV. Policies and measures

An overview of the implemented and planned policies and measures was provided to support the implementation of the building renovation roadmap, including information such as: short description, quantified objectives, type of policy or measures (such as legislative, economic, fiscal, training, awareness), planned budget and funding sources, date of entry into force, etc.

The identification and design of the policies and measures was performed taking into consideration the outcomes of the PESTEL analysis and the objectives of the building renovation roadmap. It should be mentioned that the described policies and measures are in full alignment with the provisions of the National Energy Climate Plans and other relative strategies for the renovation of the building stock. Nevertheless, the tailor-made design of the described policies and measures was occurred taking into consideration the characteristics of the energy poor households.

A combination of policies and measures was proposed in order to support the alleviation of energy poverty through the deep renovation of the buildings. Indisputably, the provision of subsidies was considered as the most effective means of economic support covering significantly the investment cost. In any case, the subsidy rate should be decided so as 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.

V. Deep renovation investment needs

The investment needs, which are required for the implementation of the building renovation roadmap, for the predefined timeline 2030, 2040, 2050, were calculated including their distinction between public investments and private investments. Moreover, the potential financing sources were described in conjunction with the planned policies and measures.

VI. Monitoring and evaluation framework

A holistic monitoring and evaluation framework was established to monitor and assess the implementation of the building renovation roadmap and the realisation of the planned investments for each building renovation roadmap. 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). Also, the responsible authority was appointed for the proposed monitoring and evaluation mechanism.

The implemented energy efficiency and RES investments should be evaluated using cost-effectiveness and/or cost-benefit analyses. The aim of the analysis is to assess the effectiveness of the implemented policies and measures so as to decide either their continuation, or their improvement or their replacement with new more effective ones so as to achieve the specified renovation targets. Furthermore, the potential deviations have to be estimated comparing the expected performance to the actual one. The adjustment of the building renovation roadmap

should be initiated in the case of deviations based on a pre-defined threshold should (e.g., 10% deviation).

Synopsis of the developed REVERTER Roadmaps

The REVERTER roadmaps for the project pilot areas, i.e. Brezovo, Athens Urban Area, Riga and Coimbra, are presented in detail in Annexes I, II, III and IV of the present deliverable. A brief description of the roadmaps developed for each pilot is provided hereinafter.

Brezovo pilot

Three different roadmaps were developed for the Municipality of Brezovo to alleviate energy poverty:

Roadmap I (Single-Family Buildings Roadmap) aims to accelerate the renovation of single-family buildings occupied by energy-poor households. The total number of single-family houses to be renovated was estimated considering that 20% of the households in the area are affected by energy poverty. Based on the home visits conducted so far and expert assessment, insulation of the building envelope, replacement of old inefficient heating/cooling systems and RES interventions (installation of solar thermal systems and roof PV installations) are recommended. Focusing specifically on renovations triggered by the project (i.e. till the end of the project and 5 years beyond project-end), the impacts are summarised in Table ES1. It is noted that the planned investments will be carried out with 100% public funding.

Table ES1. Contribution of the REVERTER project to the renovation of single-family buildings in Brezovo, in the period 2025-2030.

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

Roadmap II (Multi-Family Buildings Roadmap) intends to alleviate energy poverty in two multi-family buildings. The first building has three sections with 3 floors each and the total built-up area is 1,794 m². The second building consists of two sections of 4 floors and each section has six apartments. The total built-up area is 1,380 m². The energy renovation measures include building envelope measures, replacement of inefficient heating systems, and individual RES installations, namely photovoltaic installations for own consumption and solar thermal installations for hot water heating. The overall impacts of the project (i.e. till the end of the project and 5 years beyond project-end) regarding the deep renovation of the two buildings are summarised in Table ES2. For conservativeness reasons, it is assumed that the planned investments will be carried out with 80%

public funding and 20% private funding. Nevertheless, it is expected that the National Decarbonization Fund will support energy-poor households with 100% financing.

Table ES2. Contribution of the REVERTER project to the renovation of multi-family buildings in Brezovo, in the period 2025-2030.

Impacts	Energy-poor households Tenants –Apartments in MFBs
Number of renovated dwellings	24
Resulted cumulative final energy savings (GWh)	0.174
Resulted cumulative primary energy savings (GWh)	0.321
Resulted cumulative CO_2 reduction (ktn CO_2)	0.058
Resulted employment impacts (person-years)	9.4
Resulted cumulative multiple benefits (million €)	0.0037
Required new investments (million €)	0.6

Roadmap III (Social Buildings Roadmap) focuses on the renovation of two social buildings in the Municipality of Brezovo. The social buildings are family-type accommodation centres that offer residential-type social services as well as additional services (e.g. medical supervision and psychological support for children deprived of parental care). The two buildings accommodate a total of about 25 vulnerable people. On-site visits and expert assessment of the two social housing buildings established the need for building envelope interventions, the transition from liquid or solid fuel (raw biomass) to modern and effective heat pump heating, and the installation of roof PV and solar collectors for DHW. The overall impacts of the project (i.e. till the end of the project and 5 years beyond project-end) regarding the two social buildings are summarised in Table ES3. It is noted that the planned investments will be carried out with 100% public funding.

Table ES3. Contribution of the REVERTER project to the renovation of the two social buildings in Brezovo, in the period 2025-2030.

Impacts	Energy-poor households – Social buildings
Number of newly renovated buildings	2
Resulted cumulative final energy savings (GWh)	0.118
Resulted cumulative primary energy savings (GWh)	0.311
Resulted cumulative CO_2 reduction (ktn CO_2)	0.042
Resulted employment impacts (person-years)	12.8
Resulted cumulative multiple benefits (million €)	0.0025
Required new investments (million €)	0.826

Athens Urban Area pilot

Three different roadmaps have been developed in the Athens Urban Area pilot towards alleviating energy poverty:

Roadmap I (Tenants in Athens Urban Area) aims to accelerate the deep renovation of tenant dwellings (both single-family buildings and apartments in multi-family buildings). The total building stock to be renovated by 2050 was calculated considering the old building stock (i.e. before 2005), the percentage of households affected by energy poverty (15%), and the percentage of energy-poor

households who rent their residences (21%). To estimate the renovation costs three different renovation schemes were modelled and analysed. Combining building envelope interventions with heat pumps and solar thermal systems constitutes a meaningful deep renovation option. 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 ES4, while the allocation of the total investments to public and private investments triggered by the project is presented in Table ES5.

Table ES4. Contribution of the REVERTER project to the renovation of privately-rented dwellings in the Athens Urban Area, 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 ES5. Allocation of the total investments to public and private investments triggered by the REVERTER project (million €) in the Athens Urban Area for privately-rented dwellings, 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

Roadmap II (Owner-occupied apartments in multi-family buildings in Athens Urban Area) intends to alleviate energy poverty in vulnerable households living in owner-occupied apartments. The total building stock to be renovated by 2050 was calculated considering the old multi-family buildings (i.e. before 2005), the percentage of households affected by energy poverty (15%), and the average number of households per multi-family building. To estimate the renovation costs building envelope interventions and installation of heat pumps and solar thermal systems were considered based on

the analysis of three different renovation packages. Focusing only on renovations triggered by REVERTER (i.e. till the end of the project and 5 years beyond project-end), it is estimated that 186 owner-occupied apartments will be retrofitted. The overall impacts of the project are summarised in Table ES6, while the allocation of the total investments to public and private investments triggered by the project is presented in Table ES7.

Table ES6. Contribution of the REVERTER project to the renovation of owner-occupied apartments in the Athens Urban Area, in the period 2025-2030.

Impacts	Energy-poor households - Owner-occupied apartments in multi-family buildings (MFB)
Number of newly renovated buildings	186
Resulted cumulative final energy savings (GWh)	1.92
Resulted cumulative primary energy savings (GWh)	2.50
Resulted cumulative CO_2 reduction (ktn CO_2)	0.53
Resulted employment impacts (person-years)	79.81
Resulted cumulative multiple benefits (million €)	0.08
Required new investments (million €)	5.15

Table ES7. Allocation of the total investments to public and private investments triggered by the REVERTER project (million €) in the Athens Urban Area for owner-occupied apartments, in the period 2025-2030.

Period	Roadmap	Energy poor households	Share	Public funds	Private (own) funds	Total
2025-2030	**Energy-poor households - Owner-occupied apartments in multi-family buildings (MFB)**	**Category I**	20%	0.51	0.51	1.03
		Category II	30%	1.16	0.39	1.54
		Category III	50%	2.32	0.26	2.57
		Total	100%	3.99	1.16	5.15

Roadmap III (Owner-occupied single-family houses in Athens Urban Area) focuses on tackling energy poverty in vulnerable households living in owner-occupied single-family buildings. The total building stock to be renovated by 2050 was calculated considering the old single-family buildings (i.e. before 2005), and the percentage of households in owner-occupied single-family houses and affected by energy poverty (15%). To estimate the renovation costs building envelope interventions and installation of heat pumps and solar thermal systems were considered based on the analysis of three different renovation packages. Focusing only on renovations triggered by REVERTER (i.e. till the end of the project and 5 years beyond project-end), it is estimated that 28 owner-occupied single-family houses will be retrofitted. The overall impacts of the project are summarised in Table ES8, while the allocation of the total investments to public and private investments triggered by the project is presented in Table ES9.

Table ES8. Contribution of the REVERTER project to the renovation of owner-occupied single-family houses in the Athens Urban Area, in the period 2025-2030.

Impacts	Energy-poor households - Owner-occupied single-family houses
Number of newly renovated buildings	28
Resulted cumulative final energy savings (GWh)	0.83
Resulted cumulative primary energy savings (GWh)	1.03
Resulted cumulative CO_2 reduction (ktn CO_2)	0.22
Resulted employment impacts (person-years)	19.65
Resulted cumulative multiple benefits (million €)	0.03
Required new investments (million €)	1.27

Table ES9. Allocation of the total investments to public and private investments triggered by the REVERTER project (million €) in the Athens Urban Area for owner-occupied single-family houses, in the period 2025-2030.

Period	Roadmap	Energy-poor households	Share	Public funds	Private (own) funds	Total
2025-2030	**Energy-poor households - Owner-occupied apartments in multi-family buildings (MFB)**	**Category I**	20%	0.13	0.13	0.25
		Category II	30%	0.29	0.10	0.38
		Category III	50%	0.57	0.06	0.63
		Total	100%	0.98	0.29	1.27

Riga pilot

The aim of the Roadmap "Multi-family buildings in Riga" is to help tackle energy poverty in vulnerable households living in multi-family buildings (MFBs) in Riga. The Roadmap provides a pathway to upgrade a total of around 3,800 MFBs, by 2050 giving focus both on landlords and tenants. A total area of 2,100 thousand m^2 of the buildings to be renovated is occupied by energy-poor households, considering the percentage of households affected by energy poverty (20%). To estimate the renovation insulation of the building envelope with EPS was selected because it has the best performance and meets or exceeds the targets for deep renovation. 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 13 MFBs will be retrofitted (3 MFBs during project implementation and 10 MFBs five years after the completion of project). The overall impacts of the project are summarised in Table ES10, while the allocation of the total investments to public and private investments triggered by the project is presented in Table ES11.

Table ES10. Contribution of the REVERTER project to the renovation of MFBs in Riga, in the period 2025-2030.

Impacts	Energy-poor households - Multi-family houses- Apartments (MFB)
Number of new renovated buildings	13
Resulted cumulative final energy savings (GWh)	0.55
Resulted cumulative primary energy savings (GWh)	0.49
Resulted cumulative CO_2 reduction (ktn CO_2)	0.16
Resulted employment impacts (person-years)	21.39
Resulted cumulative multiple benefits (million €)	0.006
Required new investments (million €)	1.38

Table ES11. Allocation of the total investments to public and private investments triggered by the REVERTER project (million €) in Riga for MFBs, in the period 2025-2030.

Period	Roadmap	Energy poor households	Share	Public funds	Private (own) funds	Total
2025-2030	**Energy-poor households Multi-family houses- Apartments (MFB)**	**Category I**	80%	0.55	0.55	1.10
		Category II	20%	0.25	0.03	0.28
		Total	**100%**	0.80	0.58	1.38

Coimbra pilot

Two different roadmaps were developed for the Municipality of Coimbra to alleviate energy poverty:

Roadmap I (Social Multi-Family Buildings in Coimbra) aims to help vulnerable households living in social MFBs to improve their comfort levels and reduce their energy bills. Roadmap I provides a pathway for local, regional and national authorities to upgrade around 3,400 apartments in MFBs in the Municipality of Coimbra, by 2050. The abovementioned figures were calculated taking into account the number of MFBs constructed before 2005, the average number of households dwelling in MFBs, and the percentage of energy-poor households in the Municipality of Coimbra (i.e. 17.5%, for details refer to Section 2). To estimate the renovation costs four different renovation schemes were modelled and analysed. The solutions focus on the energy renovation of the building envelope and the installation of renewable energy sources. The replacement of windows and doors, and the installation of a new heat pump and PV panels had the best performance on the examined indicators and was, therefore, selected. Focusing specifically on the renovations triggered by REVERTER (i.e. till the end of the project and 5 years beyond project-end), it is estimated that 32 dwellings (apartments in four social multi-family buildings) will be retrofitted. The overall impacts of the project are summarised in Table ES12. Since the buildings are social houses owned by the Municipality, the investment cost will be covered entirely by public funds.

Table ES12. Contribution of the REVERTER project to the implementation of the specific roadmap for the renovation of apartments in social MFBs in Coimbra, in the period 2025-2030.

Impacts Roadmap I	Energy-poor households - Apartments in social multi-family buildings (MFB)
Number of newly renovated apartments	32
Resulted cumulative final energy savings (GWh)	0.222
Resulted cumulative primary energy savings (GWh)	0.556
Resulted cumulative CO_2 reduction (ktn CO_2)	0.0336
Resulted employment impacts (person-years)	4.9
Resulted cumulative multiple benefits (million €)	0.0135
Required new investments (million €)	0.319

Roadmap II (Social Single-Family Buildings in Coimbra) aims to lead vulnerable households living in detached houses to find solutions to improve their comfort levels and reduce their energy bills. Specifically, Roadmap II provides a pathway for local, regional and national authorities to upgrade around 6,700 single-family buildings (SFBs) in the Municipality of Coimbra, by 2050. The abovementioned figures were calculated considering the number of SFBs constructed before 2005, and the percentage of energy-poor households in the Municipality of Coimbra (i.e. 17.5%, for details refer to Section 2). To estimate the renovation costs four different renovation schemes were modelled and analysed, exploring not only the energy renovation of the building envelope but also the advantages of adopting renewable energy sources. The replacement of windows and doors, and the installation of a new heat pump and PV panels had the best performance on the examined indicators, and therefore it was selected for Roadmap II. Focusing specifically on the renovations triggered by REVERTER (i.e. until the end of the project and 5 years beyond project-end), it is estimated that 9 social SFBs will be retrofitted. The overall impacts of the project are summarised in Table ES13. Since the dwellings are social houses owned by the Municipality, the investment cost will be covered entirely by public funds.

Table ES13. Contribution of the REVERTER project to the implementation of the specific roadmap for the renovation of social SFBs in Coimbra, in the period 2025-2030.

Impacts Roadmap I	Energy-poor households - Social single-family buildings (SFB)
Number of newly renovated apartments	9
Resulted cumulative final energy savings (GWh)	0.071
Resulted cumulative primary energy savings (GWh)	0.176
Resulted cumulative CO_2 reduction (ktn CO_2)	0.0107
Resulted employment impacts (person-years)	0.9
Resulted cumulative multiple benefits (million €)	0.0043
Required new investments (million €)	0.059

The overall contribution of the REVERTER project is summarised in Table ES14 for each pilot separately.

Table ES14. Contribution of the REVERTER project to deep renovations of dwellings occupied by energy-poor households in the four pilots, in the period 2025-2030.

Pilot	Brezovo			Athens Urban Area			Riga	Coimbra	
Roadmap	I	II	III	I	II	III	I	I	II
Number of newly renovated buildings	48	24	2	61	186	28	13	32	9
Resulted cumulative final energy savings (GWh)	0.35	0.174	0.118	0.78	1.92	0.83	0.55	0.222	0.071
Resulted cumulative primary energy savings (GWh)	0.64	0.321	0.311	1.00	2.50	1.03	0.49	0.556	0.176
Resulted cumulative CO_2 reduction (ktn CO_2)	0.12	0.058	0.042	0.21	0.53	0.22	0.16	0.0336	0.0107
Resulted employment impacts (person-years)	30.3	9.4	12.8	28.33	79.81	19.65	21.39	4.9	0.9
Resulted cumulative multiple benefits (million €)	0.007	0.0037	0.0025	0.04	0.08	0.03	0.006	0.0135	0.0043
Required new investments (million €)	1.95	0.6	0.826	1.83	5.15	1.27	1.38	0.319	0.059

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Glossary

Abbreviation / acronym	Description
NECPs	National Energy and Climate Plans
LTRS	Long-Term Renovation Strategies
EP	Energy Poverty
EED	Energy Efficiency Directive
EPBD	Energy performance of buildings directive
OSS	One-stop shop
LCA	Life Cycle Assessment
SFB	Single-family buildings
MFB	Multi-family buildings
EU-SILC	European Union Statistics on Income and Living Conditions
GWh	Gigawatt Hours
RES	Renewable energy sources
RAs	REVERTER Ambassadors
NGOs	Non-governmental organisations
Vulnerable citizen/consumer	The term is used interchangeably throughout the document for individuals.

1 Introduction

The preparation of the REVERTER renovation roadmaps in the four targeted pilot areas of the project is foreseen within the framework of Task 3.5. The REVERTER roadmaps aim to combat energy poverty by addressing the poor energy efficiency of dwellings through the deep renovation of the building stock. More specifically, the renovation roadmaps will be developed taking into consideration both the derived conclusions and policy recommendations resulting from the analysis of the best practices and the different characteristics and conditions of the targeted countries, which are detailed in Deliverables 2.1 and 3.2.

A political, economic, social, technological, environmental and legal (or PESTEL) analysis was carried out for each pilot to identify the most relevant challenges and issues, which must be considered during the preparation of the roadmaps. Indicatively, the characteristics of the building stock, the different types of vulnerable households and the climate conditions were considered allowing the larger-scale rollout and replication of the proposed actions within the roadmaps. Furthermore, to facilitate the development of homogeneous renovation roadmaps, a template was prepared. Emphasis was given on the defined renovation targets, the existing and planned policies and measures, the time plan and milestones for the completion of the foreseen investments, the financial instruments etc. In this direction, a guidance note was compiled describing all the required actions for the preparation of the renovation roadmaps, while regular meetings were organised to technically support the development of the roadmaps. Finally, dedicated consultation activities were designed in each pilot for discussing the preparation.

To replicate the development of deep renovation roadmaps in other regions, the deliverable distinguishes between the methodological framework, which is discussed in the main body of the report, and the REVERTER roadmaps, which are detailed in annexes. To keep the main text concise and compact and to avoid unnecessary repetition, in the pilot areas where the development of more than one roadmap is foreseen, duplication of common contents (e.g. institutional framework, energy poverty characteristics, etc.) is avoided and only the parts of the roadmaps that differ are separated.

The rest of the document is structured, as follows: Section 2 discusses the methodological steps followed for the development of the roadmaps. The REVERTER renovation roadmaps are presented in Annex I (Brezovo, Bulgaria), Annex II (Athens Urban Area, Greece), Annex III (Riga, Latvia), and Annex IV (Coimbra, Portugal), respectively.

2 The REVERTER Roadmaps

2.1 Scope and main principles of the REVERTER Roadmaps

The REVERTER roadmaps aim to combat energy poverty by addressing the poor energy efficiency of dwellings through the deep renovation of the building stock. The selection of the deep renovation measures was performed to ensure the long-term alleviation of energy poverty.

The building renovation roadmaps are tailor-made to the characteristics of the building stock, the characteristics of the vulnerable households, the legislative framework and the climate conditions of each pilot, while they intend to cover a sufficiently cohesive group of cases that will allow for a larger-scale rollout and replication of the proposed actions for the effective analysis and tackling of the problem.

The building renovation roadmaps target the worst-performing homes first (worst first principle), cope with split-incentive dilemmas and address various market, information and behavioural failures. Moreover, the most cost-effective energy efficiency and RES interventions are promoted (best-possible principle) ensuring the maximisation of the various economic, energy, climate and social benefits triggered by the implementation of the required energy efficiency and RES interventions.

A well-balanced combination of policies and measures will be proposed considering the actual capability of the involved end-users to provide their own funds with an objective and transparent approach. During the pilot implementation phase of the project, emphasis will be given to the establishment of one-stop shops (OSS) as defaults for the enrolment of vulnerable households in subsidised energy efficiency improvement programmes for buildings and for reinforcing the existing level of knowledge both about the energy poverty phenomenon and the deep renovation measures.

2.2 REVERTER Roadmaps methodological steps

2.2.1 Specification of the main objectives

Firstly, the analysis of the main objectives of the building renovation roadmap must be carried out. The main objective of the building renovation roadmaps should be the confrontation of energy poverty through the deep renovation of the buildings, which are inhabited by energy-poor households.

The maximization of the economic, energy, climate and social benefits triggered by the implementation of the required energy efficiency and RES interventions is considered a prerequisite for the achievement of the main objective of the building renovation roadmap. In this direction, the focus should be given to the identification of the worst-performing buildings and the most cost-effective energy-efficient and RES interventions.

Finally, additional objectives can be specified also, such as indicatively the improved indoor air quality, the job-creation, the avoidance of health impacts etc.

2.2.2 Preparatory actions for the development of the roadmap

2.2.2.1 Legislative and policy framework

The existing legislative and policy framework, which is related directly and indirectly to the renovation of the building stock, must be described at the national, regional and local levels, including the existing strategies. Moreover, the main policies and measures have to be described including quantitative information about their contribution to the energy upgrade of the building stock.

Emphasis must be given on the presentation of the main energy, environmental and climate change legislative and policy frameworks at the national level. The analysis should cover indicatively the following issues:

- The adopted national legislation, which enables and accelerates the renovation of the building stock.
- The defined energy and climate targets.
- The specified minimum requirements that must be fulfilled during the renovation of residential buildings.
- The legislative framework for the licensing of energy efficiency and RES interventions.

Finally, the legislative context for combating energy poverty must be also analysed, including information both about the targets for the alleviation of energy poverty and the implemented and planned policies and measures.

2.2.2.2 Identification of key stakeholders

The implementation of the envisaged building renovation roadmaps requires the involvement of various bodies and authorities, which are illustrated in Figure 1.

The mapping of the involved bodies and authorities leads to the conclusion 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 energy-poor households towards 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 national, regional and local levels.

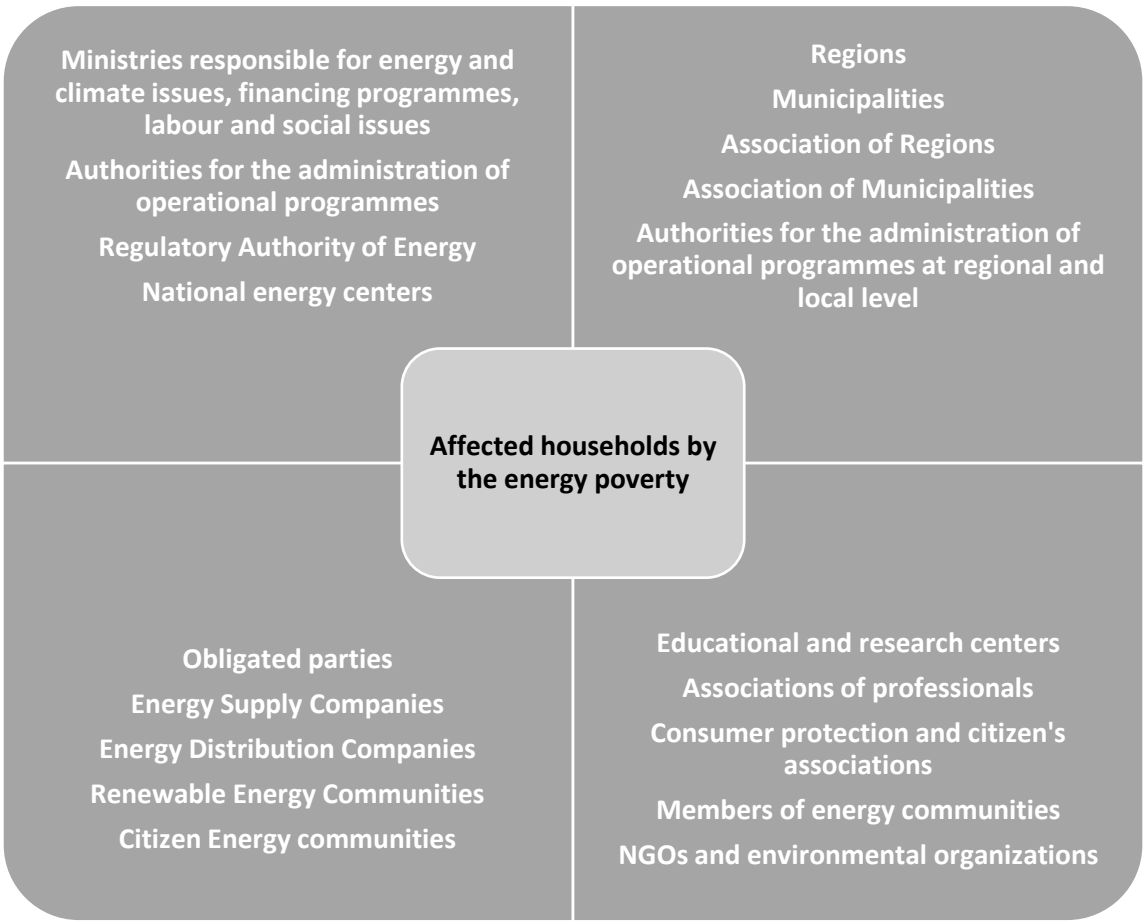

Figure 1. Overview of the involved categories of stakeholders into the preparation of the building renovation roadmap.

2.2.2.3 Analysis of the current levels and characteristics of energy poverty

A detailed analysis of the characteristics of energy poverty should be conducted based on different energy poverty indicators. The energy poverty indicators should be developed at regional and local levels facilitating the definition of the energy-poor households' profile based on their beliefs, challenges, values, etc.

Moreover, the calculated energy poverty indicators can be compared to the respective ones, which have been estimated at the national level, in order to identify the parameters that lead to the observed differences.

A combination of energy poverty indicators can be utilised, both qualitative and quantitative, to capture all the parameters, which are related to energy poverty such as (indicatively):

- Income
- Energy expenses
- Energy performance of the building
- Characteristics of the building
- Actual nature of energy access
- Degree of choice and availability of energy carriers
- Utilisation of technical systems and other equipment

- Ownership of the building
- Type and flexibility of the built environment (e.g. limitations to making modifications to the home due to tenancy status).
- Inadequate dwelling conditions (e.g., leaking roof) or inadequate thermal comfort conditions.
- Health impacts
- Everyday practices and cultural habits

If necessary, the collected data within the framework of primary social surveys could be used besides the data for administrative sources (e.g. HBS, EU SILC, building and households census, etc).

The outcome of the analysis will be the number of households, which can be classified as energy poor in the targeted area. Furthermore, the number of energy-poor households, which inhabit different types of owner-occupied buildings (e.g. detached houses, multi-apartment buildings, condominiums etc.) and rented properties is also required.

2.2.2.4 Analysis of the building stock

The existing building stock should be analysed based on data retrieved by existing databases (e.g. Census data, Energy Performance Certificate databases, etc.) or in situ surveys to determine the energy efficiency of residential buildings.

The performed analysis should provide quantitative information for the building stock about the construction period, the climatic zone, the energy consumption and the utilised energy carriers for each end-use separately, the energy performance as outlined by the energy class of the issued energy performance certificates, etc. It should be noted that the calculated data should be estimated for each building type separately.

Priority should be given to the collection of actual or/and metered data. In the case that actual data are not available, estimated data can be used alternatively with assumptions that will be based on valid and robust data sources.

An indicative list of the proposed indicators is presented in the following box:

Proposed indicators

1. Number of buildings and total floor area (m^2):

- per building type (including social housing)

- per energy performance class

- for the case of NZEB

- for the case of worst-performing buildings

2. Number of buildings and total floor area (m^2):

- per building age

- per building size

- per climatic zone

3. Annual renovation rates: number and total floor area (m^2):

- per building type

- to nearly zero-energy building levels

- per renovation depth (weighted average renovation)

4. Primary and final annual energy consumption (ktoe):

- per building type

- per end use

5. Average primary energy use (kWh/m^2) for residential buildings

6. Installed capacity of the renewable energy technologies in buildings (MW generated) for each RES technology separately:

- on-site

- off-site

7. Production of renewable energy in buildings (MWh generated) for each RES technology separately:

- on-site

- off-site

8. Reduction in energy costs (EUR) per household (average)

9. Annual greenhouse gas emission reduction ($kgCO_2eq/m^2$)

2.2.2.5 Prioritisation in the context of the "worst first" principle

The energy renovation of the worst-performing buildings should be prioritised. The identification of the worst-performing buildings will be carried out within the framework of the analysis of the building stock, as described in the previous step.

Moreover, the energy-poor and inefficient hotspots should be identified in vulnerable districts, clusters of buildings with vulnerable residents and groups of buildings with common management

to enhance the context of the worst first principle and complement the analysis of the building stock.

The combination of the conducted analyses will facilitate the association of energy poverty with the characteristics of the buildings and the area under consideration (e.g. multifamily, private rented, social housing, income, etc.), in addition to the construction age, as well as with climatic data.

2.2.2.6 Identification and confrontation of the barriers

The identification of barriers is considered a meaningful step for the further promotion of deep renovation to tackle energy poverty.

A PESTEL (Political, Economic, Social, Technological, Environmental and Legal) analysis should be performed to identify the most important parameters and the main market barriers and market failures (administrative, financial, technical, awareness and other) in the area of interest. Moreover, solutions will be proposed to address the identified barriers. In this direction, PESTEL analysis is a strategic business-planning tool used to identify, analyse, and control major external macro-environmental factors (Political, Economic, Social, Technological, Environmental and Legal), which affect an examined issue, such as the building renovation policies and measures. These factors can be defined as the general legislative context, the global business conditions, the role of various entities, the events, and other factors.

The PESTEL analysis involves the five following steps:

- Step 1: Speculate the PESTEL factors: Collect and analyse information on the relevant political, economic, social, technological, environmental, and legal factors, which are related to the building renovation interventions.
- Step 2: Identify and map all the relevant PESTEL factors: Map the PESTEL factors, identify and evaluate those that affect the building renovation interventions, by either representing a potential threat or opportunity.
- Step 3: Assess the level of impact of PESTEL factors: Assess individually the level of impact of each PESTEL factor using the appropriate scoring system to better recognise the opportunities and challenges the building renovation interventions.
- Step 4: Identify opportunities and threats: Identify the opportunities and threats that each of the PESTEL factors, which affect the effectiveness of the building renovation interventions.
- Step 5: Select the most effective policies and measures: Identify the policies and measures, which are required to implement the results of the PESTEL analysis, along with the potential risks or threats and the required measures to mitigate or eliminate them.

The PESTEL analysis will be carried out through the completion of Table 1.

Firstly, the main factors, which affect the building renovation roadmaps, must be identified. Indicative external factors are presented for further consideration and analysis. Finally, the identified factors should be assessed in regard to their importance using a qualitative scale (high, medium or low importance).

Table 1. PESTEL analysis table.

	External factors to consider	Factors affect building renovation roadmaps	Importance to the renovation roadmap (High-medium-low)
Political	*EU directives focused on 2050* *Governance structures (e.g., formal or non-formal structures that supports governance* *Incentives/financial Measures* *Pending legislation changes* *Policy goals/specified national targets (e.g., in energy, environment, regional development)* *Political stability and renumeration framework*		
Economic	*Availability of lending funds* *Capacity of construction and energy sector* *Competitiveness* *Cost of living* *Demand for building renovation and energy services* *Economic development patterns (future trend)* *Economic growth/decline (current status)* *Energy expenses* *Energy prices* *Energy services companies* *Energy taxation* *Inflation* *Interest rates* *Labour costs* *Prevailing economic sectors in terms of GVA with competitive advantages* *Skilled energy efficiency professionals* *Split incentives* *Unemployment*		
Social	*Career attitudes* *Demographics* *Energy consumption & production patterns* *Institutional capacity* *Level of awareness on delivered impacts by RES and energy efficiency* *Lifestyle factors* *Participatory culture* *Population* *Rates and characteristics of energy poverty in the population*		

	External factors to consider	Factors affect building renovation roadmaps	Importance to the renovation roadmap (High-medium-low)
	Rates and characteristics of general poverty in the population *Resistance to change* *Role of prosumers* *Social capacity* *Social residence towards RES* *Society's levels of health, education, and social mobility* *Work-life balance*		
Technology	*Artificial Intelligence* *Automation* *Degree of digitalization of the energy sector* *Disruptive technologies* *Innovation* *New energy saving technologies* *Renewables technologies* *Smart city platforms* *Smart meters deployment* *Social networking*		
Environment	*Adaptation policies* *Circular economy* *CSR (Corporate social responsibility)* *Environmental objectives* *Environmental programs/partnerships* *Environmental restrictions imposed by in-country governments* *Ethical sourcing* *Future pandemics* *Procurement* *Sustainable energy resources/potential* *Transportation* *Waste management*		
Legal	*Common law* *Data protection law* *Employment law* *Health and safety regulations* *Legislative and regulatory framework (e.g., for energy, spatial planning, environment, regional development)* *Level of compliance with the laws* *Local labour law* *Laws & regulations on permissions and licenses (e.g., for renewables installations, buildings, production sites etc)*		

2.2.2.7 Establishment of OSSs

One of the most fundamental pillars of the building renovation roadmaps is the establishment of One-stop shops (OSSs) in order to overcome the classic renovation model, referred to as the "atomised model" that requires the homeowner (or the renter) to make all major decisions, keep in touch with all suppliers and partners involved, invest a lot of time and take risks.

The OSSs may offer "integrated solutions" as a service, transforming a cumbersome and complex set of decision-making/actions by non-experts, and especially vulnerable people, into a single-entry, customer-friendly offer. In this way, OSS can address the market fragmentation barriers on both demand and supply sides, overcoming some of the sociotechnical barriers surrounding the decision to renovate holistically.

Different business models can be utilised according to INNOVATE project providing different services such as indicatively:

- Facilitation model, e.g. reinforce awareness about energy renovation benefits, inform about the optimal renovation works, advice for the different steps, etc. This is the business model adopted in REVERTER.
- 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 in 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 in all renovation steps.

The OSSs will also facilitate 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.

Therefore, a specialised measure should be designed and implemented for the establishment and operation of the OSSs in order to tackle energy poverty through the deep renovation of the residential buildings.

2.2.3 Methodology for the development of the REVERTER Roadmaps

The building renovation roadmap should result from the implementation of a methodological approach, which consists of four different steps (Figure 2).

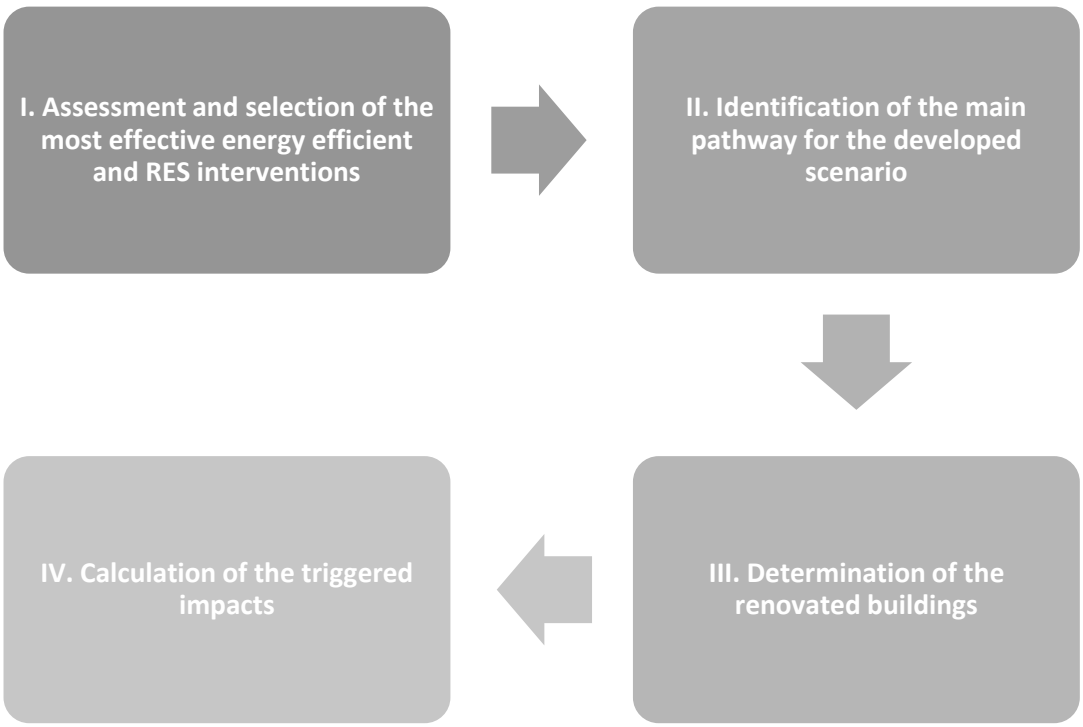

Figure 2. Applied methodological approach.

Firstly, the assessment and selection of the available energy efficient and RES interventions should be carried out in Step I (Assessment and selection of the most effective energy efficient and RES interventions). Different combinations of energy efficiency and RES interventions should modelled to evaluate their performance and to select the most cost-effective ones considering the cost-effectiveness ratio based on the delivered energy savings and CO_2 emission reduction under the precondition that leads to the deep renovation of the building stock. It should be noted that unitary metrics must be calculated for the most effective combinations of energy efficient and RES interventions.

The following unitary metrics are recommended for the calculation of the triggered impacts:

- Final energy savings annually (kWh)
- Primary energy savings annually (kWh)
- CO_2 emission reduction annually (kg CO_2)
- Investment cost (€)
- Cost savings annually (€)

The main pathway for combating energy poverty through the renovation of the building stock has to be identified in Step II (Identification of the main pathway for the developed scenario) taking into account the selected energy-efficient and RES interventions within the framework of Step I. The identification of the main pathway is linked also with the specified renovation target and subsequently with the target for the alleviation of energy poverty. Different pathways and targets must be selected for the different types of buildings.

The selection of the main pathway may be the outcome derived from the analysis of different scenarios (pathways). Furthermore, the selection of the pathway and the specification of the

renovation and energy poverty targets should be performed taking into consideration the outcomes of the PESTEL analysis.

Moreover, the number of renovated buildings should be calculated for the formulated pathway in Step III (Determination of the renovated buildings), while the utilisation of unitary metrics for the most effective energy efficient and RES interventions will be used for the quantification of the triggered impacts in Step IV (Calculation of the triggered impacts).

The selected building renovation roadmaps must include the trajectory of the established targets for 2030, 2040 and 2050 including at least information about the annual energy renovation rate, the primary and final energy consumption of the building stock, the penetration of RES, the reduction of the GHG emission and the wider multiple benefits delivered by the building renovation.

An indicative list of the proposed indicators is presented in the following box:

Proposed indicators

1. Annual renovation rates: number and total floor area (m^2):

- per building type

- worst-performing

2. Expected primary and final annual energy consumption (ktoe):

- per building type

- per end use

3. Expected greenhouse gas emission reduction (%)

4. Expected wider benefits

- number of energy-poor households impacted

- % reduction of energy poverty levels

- quantified targets for various types of multiple benefits, such as number of households with improved mental and physical health, number of households with improved indoor conditions, number of households with improved quality of life, number of households helped to adapt their energy use behaviour etc.

5. Expected share (%) of renovated buildings:

- per building type

- per renovation depth

6. Installed capacity of the renewable energy technologies in buildings (MW generated)

7. Production of energy from renewable sources in buildings (MWh generated)

8. Increase of GDP (share and billion Euros)

- Creation of new jobs

Regarding the calculation of the employment impacts, it is suggested to use the respective results of the COMBI project, i.e. about 15.5 person-years/million EUR invested in building renovations.

Finally, the expected cumulative multiple benefits can be also estimated considering the results of the COMBI Project (https://combi-project.eu/tool/).

2.2.4 Proposed policies and measures

An overview of the implemented and planned policies and measures should be provided to support the implementation of the building renovation roadmap. For each policy and measure, the following information should be provided:

- Short description
- Quantified objectives
- Type of policy or measures (such as legislative, economic, fiscal, training, awareness)
- Planned budget and funding sources
- Entities responsible for implementing the policy
- Affected roadmaps
- Number of affected households
- Expected impact in relation to the specified targets
- Status of implementation
- Date of entry into force
- Implementation period

The identification and design of the policies and measures should be performed taking into consideration the outcomes of the PESTEL analysis and the objectives of the building renovation roadmap. It should be mentioned that the described policies and measures must be in full alignment with the provisions of the National Energy Climate Plans and other relative strategies for the renovation of the building stock. Obviously, the tailor-made design of the described policies and measures should occur taking into consideration the characteristics of the energy-poor households.

A combination of policies and measures should be implemented to support the energy upgrade of the building envelope and the installation of energy-efficient technical systems and equipment in the residential buildings. The provision of subsidies is considered the most effective means of economic support covering significantly the investment cost. 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.

Priority can be given on the provision of subsidies, while additional financial and fiscal measures can be launched, such as the adoption of targeted tax deductions, guarantee schemes, credit lines and soft-interest loans in the case that the contribution of the planned subsidies is not sufficient.

Targeted incentives can be designed for the households that inhabit multi-family buildings in the case that all of them participate in the measure.

The mandatory implementation of the most cost-effective energy efficiency interventions and RES interventions and the promotion of nearly-zero energy buildings (nZEBs) according to the provisions of the Directive 2010/31/EU both for new and existing residential buildings should be explored boosting the renovation rate of the residential buildings.

The conduction of energy efficiency interventions providing incentives to exceed energy requirements beyond the minimum ones both for new buildings and energy-renovated residential and non-residential buildings 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 can be also fostered. The construction of passive buildings can be supported, while the installation of photovoltaic systems for the on-site production of electricity can be boosted. Targeted pilot projects can be designed to ensure the readiness of the involved professionals and the participation of energy-poor households.

The reinforcement of the role of energy performance certificates of buildings is essential, while they can be accompanied by renovation passports providing recommendations for the most cost-effective energy rehabilitation measures. The renovation passports (a) describe a sequence of renovation steps to transform a building into a zero-emission building, (b) 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 (c) contain information about potential financial and technical support. Moreover, the framework of the renovation passports can 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 can be improved.

The potential regulatory and non-regulatory barriers to energy efficiency should be removed, without prejudice to the basic principles of property and tenancy law regarding the split of incentives between the landlord and the tenant of a building or among landlords. Targeted measures can be initiated to ensure that the involved parties will not be deterred from making efficiency-improving investments that they would otherwise have made because they will not 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 landlords 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.

The promotion of energy services in residential buildings constitutes an alternative option through a holistic framework both for removing potential barriers and launching targeted financing programs for the case of energy-poor households. Firstly, the existing standard contracts can be promoted, while targeted guidelines can be developed to facilitate the design and implementation of energy efficiency projects through Energy Performance Contracts. Moreover, the implementation of technical training programmes and the provision of technical assistance will familiarise the involved parties leading to successful case studies. Specialised financing mechanisms can be applied, such as the provision of low-interest loans or guarantees to energy service providers to facilitate smooth access to financing. Finally, targeted pilot projects can be designed to promote energy performance contracts in the dwellings of energy-poor households.

The renewables self-consumers can be supported for the installation mainly of photovoltaic systems with the initiation of a dedicated support scheme including financial and fiscal incentives. The design of the support scheme for the case of energy-poor households should be carried out considering the triggered benefits due to the deployment of decentralised 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 renewables self-consumers, while transparent and fair allocation rules can be specified in the case that the renewables self-consumers are in the same building. Finally, an analysis can occur to identify potential barriers, while specific policies and measures can 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.

The role and operation of both the renewable energy communities and the citizen energy communities can be strengthened for alleviating energy poverty through the design and implementation of specialised financial instruments. Specifically, dedicated fiscal and economic incentives can be provided to foster both the further deployment of renewable energy sources and the materialisation of energy efficiency projects in residential buildings through the application of new business models.

The conduction of awareness-raising and dissemination activities can be carried out in all final energy consumption sectors with a focus on energy-poor households. Specialised awareness-raising and dissemination activities can be organised 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 familiarise the involved stakeholders with the full impact of energy efficiency.

The improvement of existing and, if necessary, establishment of new qualification, accreditation, or certification schemes can enable the context for the further promotion of deep renovation 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 budling elements that are related to the improvement of the energy performance of a building, developers of design and technical documentation). Specialised training programs can be organised, tools can be developed, and technical support can be provided within the framework of current measures taking into account the peculiarities of the energy poverty phenomenon. It should be noted that this measure can focus also on the RES professionals. Finally, the expansion of the measure can be examined to cover the accreditation and certification of energy efficiency equipment and technologies.

Energy audits can be supported financially as well. More specifically, a pilot program can 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 can be given to improving the understanding and existing level of knowledge of targeted households about energy poverty. Furthermore, the derived recommendations can be supported through the provision of financial aid.

The technical and administrative capacity of the involved policy makers should be reinforced on a continuous basis to facilitate the effective design, implementation, monitoring and evaluation of energy efficiency measures, which will facilitate the alleviation of energy poverty. Specialised training sessions can be organised and sophisticated tools and materials can be prepared ensuring 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 utilisation of deep renovations, but also the preparation of technical documentation and design brief for their implementation according to the peculiarities of energy poverty. Finally, tools can be further improved and, when needed, developed for monitoring the achievement of the established targets and the performance of the implemented policies and measures.

Finally, the implementation of innovative financing mechanisms, which will facilitate the implementation of the building renovation roadmap for combating energy poverty, should be fostered. Firstly, the main challenges, which are derived by the design and implementation of the envisaged financial measures for energy-poor households can be addressed such as the maximisation of the expected leverage, the most cost-effective exploitation of the available funds, the adoption of innovative financing tools and the active mobilisation of the domestic financial sector. All the available funds should be mobilised at national and EU levels. The effective coordination of the available financial streams is essential for the effective implementation of the planned financial measures.

In addition, the provision of technical assistance can be foreseen for facilitating the financing of energy efficiency projects. Moreover, the bankability of energy efficiency projects can be improved with the utilisation of specialised tools and methodologies so as to minimise the existing levels of risk. The implementation of a quality assurance scheme and the establishment of a methodological approach for the standardisation 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 is specifically dedicated to the financing of energy-efficient projects. Towards this direction, specialised training can be organised to achieve the above-mentioned objectives. Finally, the foreseen market-based instruments can be utilised to accelerate the renovation investments in residential buildings. More specifically, the obligated parties within the framework of the Energy Efficiency Obligation Scheme can be incentivised to focus on households, while the adoption of the legislative framework for on-bill financing can provide an alternative option for repaying the foreseen investments.

2.2.5 Deep renovation investment needs

The investment needs, which are required for the implementation of the building renovation roadmap, for the predefined timeline 2030, 2040, 2050, should be calculated including their distinction between public investments and private investments. Moreover, the potential financing sources should be described in conjunction with the planned policies and measures.

An analysis (either qualitative or quantitative) could occur in regard to the required administrative resources to assess their availability and adequacy and to decide their potential enhancement with the recruitment of additional external expertise.

2.2.6 Monitoring and evaluation framework

A holistic monitoring and evaluation framework must be established to monitor and assess the implementation of the building renovation roadmap and the realisation 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 3.

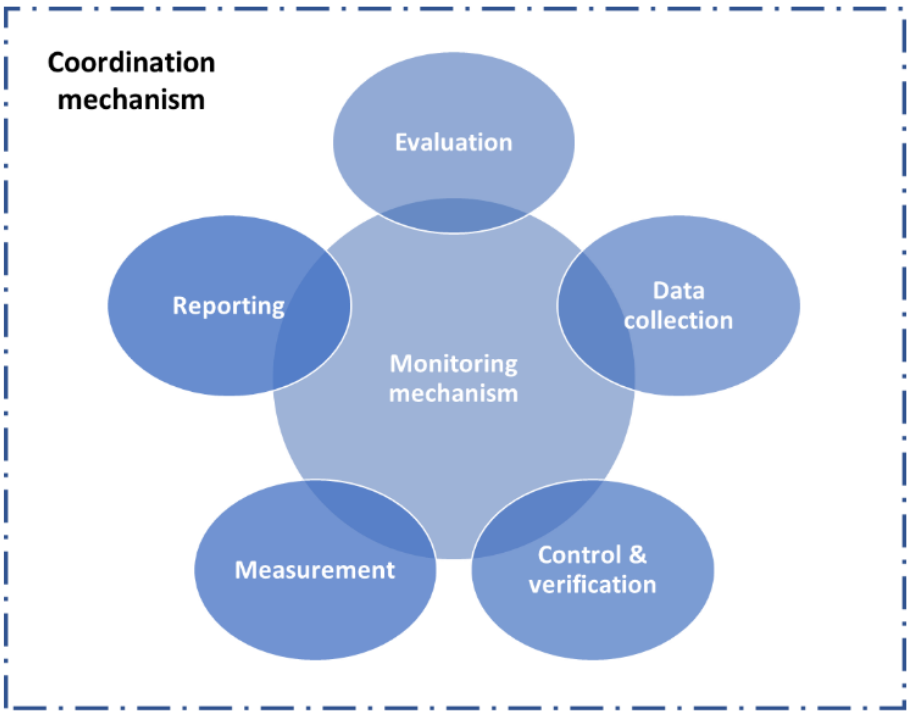

Figure 3. Overview of the sub-mechanisms within the established monitoring and evaluation framework.

The responsible authority should be appointed for the proposed monitoring and evaluation mechanism specifying the duties and responsibilities.

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. Vertical coordination ensures effective communication and administration among the different governmental levels, namely national, regional and local levels for designing and implementing energy efficiency policies and/or concrete measures. Horizontal coordination enables the effective communication and administration of the different energy efficiency measures, schemes or 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 building renovation 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 alleviating energy poverty.

The development of the measurement sub-mechanism should be implemented considering the provisions of Annex V of the Directive 2023/1791/EE. Specifically, the calculation of the achieved energy savings should be conducted through the utilisation of five different calculation methods, i.e. deemed savings, metered savings, scaled savings, surveyed savings and savings of people affected by energy poverty, vulnerable customers, people in low-income households and, where applicable, people living in social housing based on engineering estimates using standardised 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, must 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 clarify 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 specialised procedure should be implemented to control and validate the collected data following specific criteria, such as their accuracy, robustness and coherence within the control and verification sub-mechanism in Step 5. Indicative methods in order to validate the compliance with these criteria include the evaluation of the closeness between the estimated results and the true values, the comparison of the obtained results with the respective ones over time and from other spatial domains and the comparison of the estimated results with the corresponding ones from different sources or methods.

Finally, a combination of verification and control techniques (plausibility check, desktop checks, on-site checks on a specific sample and extrapolation to the total investments) to the collected data should be conducted in Step 6 to ensure the quality of the collected data as displayed in Figure 4.

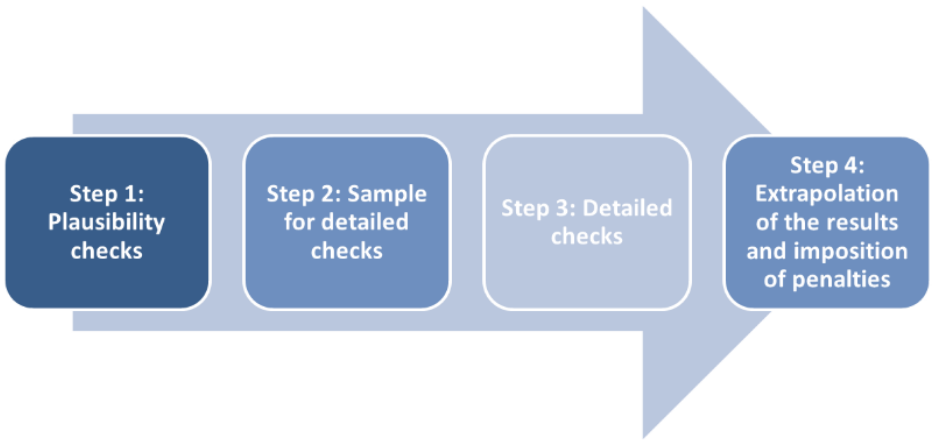

Figure 4. Steps for the conduction of the required control and verification activities.

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 investment separately. The calculation of the delivered energy savings will be performed in accordance with the selected measurement protocol. Moreover, additional quantitative information about the implementation of energy efficiency and RES investments should also be provided. It should be noted that the quantitative information must be linked with the developed bottom-up equations within the bottom-up monitoring. The required data will be collected by the implementation of both the foreseen top-down and bottom-up monitoring procedures.

A template can 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 the 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 so as to decide either their continuation, or their improvement or their replacement with new more effective ones so as to achieve the specified renovation targets.

The assessment of the implemented policies and measures can be performed 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)

Finally, 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 (e.g., 10% deviation) in order 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.

2.2.7 Communication plan

A communication plan should be prepared to communicate all the useful information for the building renovation roadmap.

The communication plan should present in detail the following steps, which must be carried out in the effective communication and dissemination of the performed activities within the framework of the building renovation roadmap:

- Step I: Analyse the communication environment, define the communication objectives and appoint the authority that will be responsible for the communication plan.
- Step II: Develop the communication materials taking into account the specified objectives and targets and the characteristics of the targeted audience.
- Step III: Identify the communication tools and utilise a combination of them to maximise the impacts.
- Step IV: Design and implement the communication activities in the short-term, medium-term and long-term horizon including accurate specification of the timeline and the required cost.
- Step V: Assess the communication activities through specific indicators, which will be quantified for each communication activity separately.

It should be noted that the conduction of consultation activities is essential for the development of the building renovation roadmaps.

Different means can be utilised in order to conduct the foreseen consultation activities, such as indicatively:

- Organisation of workshops/round tables with the participation of the identified stakeholders to discuss the main provisions of the building renovation roadmap.
- Launch an officially open consultation procedure under the auspices of the responsible ministries.
- Organisation of workshopς/round tables with the participation of the identified stakeholders to discuss the received comments during the consultation procedure.