



CEESEN-BENDER

**Building intErventions in vulNerable Districts against
Energy poveRty**

Deliverable 5.3

**Report on building – level renovation roadmaps in 5
pilot regions**

- Synthesis report -

Dissemination Level: Public

WP5 Creating roadmaps and support services for building energy renovations for vulnerable districts

Alba Iulia, August 2026



**Co-funded by
the European Union**



**CENTRAL & EASTERN EUROPEAN
SUSTAINABLE ENERGY NETWORK
CEESEN-BENDER**

Building-level renovation Roadmaps for multi-apartment buildings from CEE counties: a multi-regional synthesis

Introduction

The synthesis report is built upon the regional summaries contained within the deliverable D5.3 – Report on building-level renovation roadmaps in 5 pilot regions carried out within the scope of the CEESEN-BENDER project. This deliverable includes 5 detailed Building-level roadmaps (in the 5 pilot regions) that aim to facilitate the prioritisation of energy renovation by addressing technical (constructive) considerations, work scope, renovation investment costs, residents living conditions, and ways to ensure maximum energy efficiency and a lower carbon footprint. These roadmaps have been elaborated in national partner languages (Croatian, Polish, Romanian, Estonian, and Slovenian), along with their summaries in English, and capture the local methodologies and technical outputs for each pilot building. The synthesis of these regional results aims to highlight common cross-border lessons that have been learned through the preparation and implementation of the roadmaps. The successful elaboration of this deliverable was made possible thanks to the joint efforts of involved partners coordinated by ALEA (Alba Local Energy Agency, Romania). The elaboration was directly supported by project partners TREA, MAE, LEASP, MENE, DOOR, and UTARTU.

The roadmaps constitute the foundation of the strategic synthesis that is being presented in the next sections of the present report, providing findings on how to implement the EU's climate policy strategy in multi apartment buildings in CEE.

The full documentation of Deliverable D5.3 includes the present multi-regional synthesis report as the main summarizing document, along with the five separate Building-level roadmaps developed in the respective national languages (Croatian, Estonian, Polish, Romanian, and Slovenian), together with their English summaries, annexed here as a whole. These provide the municipalities and local technical groups from CEE countries with specific building level renovation pathways in their own language and giving the regional policymakers and international housing organizations with a strategic approach towards portfolio-wide decarbonization considering the local energy poverty and socio-economic context.

1. Executive summary

The CEESEN-BENDER project serves as a model for the long-term decarbonisation of the Central and Eastern European (CEE) building stock. The project focuses on evaluating ways for prioritisation of multi apartment buildings (MABs) renovation constructed during the rapid urbanization era — a stock characterized by extreme thermal inefficiency and technical immaturity, considering the local energy poverty and socio-economic context of the residents within these MABs. It also set out to mitigate energy poverty in MABs by bridging the technical and financial gaps that prevent deep renovation. By focusing on vulnerable residents in MABs constructed between the post war (communist) era and the 1990s, the project provides a scalable framework to move the region's most inefficient assets toward the European Union's 2050 climate neutrality targets.

The roadmaps visions are defined by several key priorities:

- **Phased deep renovation:** implementing high-performance building envelope measures (façade, roof, and basement insulation) to drastically reduce thermal demand.
- **Energy Performance Certificates migration:** transitioning buildings from a low-grade Energy Performance Certificate (EPC) class (typically C or D) to a higher-grade (typically B) - closer to climate-neutral standards.
- **Decarbonised technical systems:** integrating mechanical ventilation with heat recovery (MVHR) and high-efficiency heating/cooling solutions.
- **Renewable integration:** offsetting increased electrical loads from automation through rooftop and balcony photovoltaic (PV) deployment.
- **Social equity:** safeguarding energy-poor residents from financial displacement during the green transition.

Multi-Regional Metrics

Metric	Pilot data overview
Total Number of Pilots	30 Multi-Apartment Buildings (6 per region)
Countries Involved	Croatia, Estonia, Poland, Romania, Slovenia
Primary Building Age Range	1945 – 1990s
Target Energy Performance	Shift from Classes C/D toward Class B/Climate Neutrality
Primary Technical Focus	Envelope renovation, IEQ monitoring (improving living conditions for residents based on indoor air quality – a process based on monitoring parameters such, CO ₂ levels, temperature and humidity), RES integration

These visions serve as the foundations for addressing the specific regional typologies and socio-technical complexities detailed in this report.

2. Regional background and typological scope

In the CEE context, a "one-size-fits-all" renovation strategy is not a solution for good outcomes. The construction diversity across the five pilot regions—Medjimurje (HR), Tartu (EE), Warsaw (PL), Alba Iulia (RO), and Kidričevo/Ptuj (SI)—demands a typology-specific approach.

The building stock ranges from the precast reinforced concrete panels of Romania and Poland to the small wooden structures found in Estonia's Karlova district and the heritage-protected masonry of Slovenia. These material legacies dictate the technical complexity and investment risk of each project.

- **Precast concrete panels:** Predominant in Estonia's Annelinn district (Tartu) and Romania's Alba Iulia blocks; these buildings suffer from systemic thermal bridging and uninsulated envelopes. leading to systemic mold growth and structural degradation.

- **Structural brick masonry:** Common in the 1960s-1980s stock of Alba Iulia and the post-war residential sectors of Warsaw (Poland) and Čakovec (Croatia). These structures often feature single-glazed wooden windows and obsolete heating distribution.
- **Prefabricated concrete and post-war residential:** Found extensively across Poland and Slovenia's older stock, these typologies share common operational failures, including uninsulated roofs and basements.

Unique regional cases further complicate the intervention landscape. In Estonia, the **Karlova district** features small, two-storey wooden structures facing unique moisture management and structural integrity hurdles requiring specialized conservation pathways that require specialized hygrothermal solutions rather than standard insulation packages.

Similarly, in Slovenia, the **Kidričevo heritage sites** are governed by the Institute for the Protection of Cultural Heritage (ZVKDS), necessitating coordination on graphite EPS thickness, plaster textures, and specific material aesthetics.

These diverse architectural challenges demand the rigorous, data-driven methodologies.

3. Roadmap methodology: data-driven assessment framework

To ensure investment readiness, the CEESEN-BENDER project utilizes data-driven assessment model which is crucial for ensuring the bankability of renovations and the long-term commitment of building managers and homeowners.

The technical baseline is secured through three types of assessments:

- **IEQ monitoring:** 12-month continuous monitoring of indoor environmental quality (tracking temperature, humidity, and CO₂ concentrations) using monitoring devices and sensors to establish a baseline.
- **Sociological surveys:** Identification of energy-poor households through 400 surveys and expert group visits in each CEESEN BENDER region, focusing on residents who face "winter self-disconnection" or summertime related high temperature discomfort.
- **Stakeholder engagement:** Active mediation involving building managers and homeowners' associations to align residents' needs with technical requirements and regional financing context for MABs renovation. Success was ensured by focusing on bridging the gap between policies and residents.

This data-driven methodology exposes the systemic bottlenecks that must be addressed to unlock large-scale renovation capital.

Alongside the empirical and data driven baseline assessments there is a very systematic, sequenced or staged renovation and assessment process used in the pilot regions according to the technical and administrative maturity of each building. As opposed to one strict process, roadmaps use sequenced planning pipelines which help to move buildings from the problem definition towards the final procurement. In Estonia (Tartu), there is a dual staged readiness taxonomy which distinguishes two stages such as the investment preparation stage for buildings having completed engineering

design, energy calculations and grants applications; and the preparatory stage for those buildings which need to identify missing technical data and define the further actions. The same approach is used in Romania (Alba Iulia), where there is a staged empirical technical-engineering pipeline starting from audits and ending with DALI/feasibility studies as well as socio-economic portfolio ranking and physical works. Also, in Slovenia (Kidričevo/Ptuj) and Poland (Warsaw) there is a recommendation to implement staged physical process which begins from the critical envelope and comfort fix such as the facade insulation and ventilation efficiency, then move to the second stages like PV integration and smart energy management. In contrast, in Croatia (Medjimurje County) the technical, financial and stakeholders' aspects are integrated into one planning framework to create the baseline and enable further portfolio replication.

Taken together all these staged assessments make sure that the renovation roadmaps do not become static documents but serve as dynamic realistic tools for the decisions making process in the project regions.

4. Key challenges and bottlenecks: comparative analysis

The barriers to deep renovation in the CEE region are interdependent, requiring a multi-disciplinary mitigation strategy.

4.1 Technical and architectural challenges

Challenge	Root cause	Multi-regional mitigation
Envelope design deficiencies	Post-war precast panels and uninsulated masonry with severe thermal bridges.	Deep envelope renovation using standard high-performance materials like 13cm Graphite EPS to balance thickness and thermal efficiency.
Summer overheating	Lack of façade shading and high solar gain; temperatures peaking at 25–30°C in PL/RO.	Installation of balcony awnings, passive shading systems, and climate-resilient insulation layers.
Indoor air quality failures	Insufficient ventilation leading to night-time CO ₂ peaks (1,500–5,000 ppm) in Estonia, Poland, and Romania.	Mandating the integration of Mechanical Ventilation with Heat Recovery (MVHR) as a standard technical requirement.
Heritage constraints	Strict regulations on external aesthetics (e.g., Kidričevo, Slovenia).	Early-stage coordination with heritage institutes (ZVKDS) to adapt insulation thicknesses and finishes.

4.2 Financial and economic challenges

Challenge	Root cause	Multi-regional mitigation
Massive CapEx	Renovation costs reaching €0.8m–€1.7m per building (RO) or €2.05m total (SI).	Aggressive blending of national (PNRR/NPOO) and regional (ERDF) grant funding.

Long payback periods	ROI estimates typically between 23 and 33 years for envelope measures.	Shifting the narrative to "Non-Financial Multipliers": health, durability, and property value uplift.
High Energy Poverty	30-60% of residents vulnerable; utility costs consuming 20-40% of low incomes.	Municipal absorption of mandatory co-financing (e.g., Alba Iulia's 2% co-financing model).

4.3 Governance and legal challenges

Challenge	Root cause	Multi-regional mitigation
Decision-making hurdles	Mandatory 2/3 or high-majority homeowners' associations voting requirements (e.g., Romania).	Intensive social mediation, workshops, and visits to "demonstration buildings" to build trust.
REC regulatory gaps	Lack of clear legal provisions for Renewable Energy Communities.	Policy advocacy for building-level prosumer energy-sharing and net-metering frameworks.

4.4 Social and behavioural challenges

Challenge	Root cause	Multi-regional mitigation
Trust deficits	Resident "disruption fatigue" and historical scepticism of technical promises.	Permanent One-Stop-Shop advisory services and home-visit thermal camera inspections.
Household energy comprehension deficits	Misunderstanding the interaction between building airtightness and the need for ventilation.	Post-renovation counselling on energy management and the use of automated technical systems.

5: Multi-Regional Stakeholder Classification & Action Plan

Energy renovations in MABs involve a highly complex, multi-layered network of stakeholders across national, regional, local, and building-level actors. Securing a successful transition from technical roadmapping to physical works requires their alignment for energy renovations in MAB.

The project's stakeholders are grouped into four categories, mapping their core roles, systemic barriers, actions required to streamline the renovation pipeline

5.1 The Multi-Regional Stakeholder Alignment Matrix

The table below synthesises the ground reality of key stakeholders across the five pilot regions—Croatia, Estonia, Poland, Romania, and Slovenia—identifying root causes and targeted MAB renovation policy mitigations.

Stakeholder group	Specific regional roles & entities	Core systemic barriers	Multi-regional action & policy mitigations
Demand-side & beneficiaries homeowners, tenants, tenant representatives, and social care services	Croatia: homeowners, tenants, and co-financing representatives. Estonia: apartment associations and apartment associations boards. Poland: housing cooperatives and Warsaw cooperative managers. Romania: individual private owners and homeowners' associations. Slovenia: co-owners and residential building decision-makers.	High co-financing burden: high affordability constraints for low-income and vulnerable households. Decision-making friction: strict statutory consensus thresholds. Information gaps: low energy related knowledge regarding building physics, ventilation/ heating interactions, and available subsidies.	Targeted engagement: increase local workshops, home visits, and thermal camera demonstrations to build trust. Vulnerability shielding formally involve social care institutions and building managers to identify and financially support energy-poor households. Co-financing absorption: Public funding support for co-financing and non-eligible expenses, ensuring greater affordability and reducing upfront costs for households.
Local facilitators & technical advisers energy agencies, municipalities, and building managers	Croatia: MENE (Energy Agency), GP Stanorad Ltd., and Euroland Ltd. (building managers). Estonia: independent renovation advisers and Tartu regional facilitators. Poland: Municipal and local authorities	Technical workload: heavy administrative, technical, and procurement burdens placed on building managers and active apartment associations / homeowners associations boards. Advisory capacity deficits: limited long-term funding to sustain independent technical	One-Stop-Shops (OSS): establish and fund permanent, integrated One-Stop-Shops to provide continuous technical, legal, and administrative guidance under a single roof. Standardisation of tools: deploy open-source, simplified tools (such as the CEESEN-BENDER digital building prioritisation tool and ROI

	(Warsaw/Wawrzyszew). Romania: Alba Iulia Municipality (applicant/facilitator) and ALEA (Alba Local Energy Agency). Slovenia: Local Energy Agency (LEASP) and professional building managers.	and financial advisory services. Data gaps: incomplete or heterogeneous baseline building-performance and socio-demographic data.	Calculator) to assist local facilitators in planning. Manager capacity building: strengthen project - management capacities of building managers through structured training and step-by-step templates.
Financial & public grant providers ministries, funding funds, regional development agencies, and banks	Croatia: National Recovery and Resilience Plan (NPOO), Operational Programme Competitiveness and Cohesion (OPCC), and commercial banks. Estonia: national support/grant institutions (KredEx) and commercial banks. Poland: National funding institutions (e.g., BGK) and loan providers. Romania: Ministry of Development (MDLPA), Ministry of EU Funds (MIPE), and ADR Centru (RDA). Slovenia: Eco Fund (Eko sklad) and	Unpredictable funding: discontinuous funding calls, volatile eligibility conditions, and highly complex application requirements. Payback and credit limits: extremely long payback periods for deep envelope retrofits (23–33 years) making standard commercial credit unviable. Lack of tailored products: absence of specialized private green loan frameworks adapted to co-ownership and condominium structures.	Stable funding programs: transition to stable, multiannual public funding calls with simplified application procedures and clear schedules. Blended Financing Models: Develop hybrid financing instruments that combine public grants, preferential commercial bank green loans, and national interest-rate support. Targeted subsidy rates: introduce higher support rates or complementary public funding specifically targeting low-income and vulnerable MAB co-owners.

	national development banks.		
Technical supply chain architects, energy auditors, designers, contractors, and heritage authorities	Croatia: designers, energy experts, and contractors. Estonia: designers, energy auditors, technical consultants, and professionals. Poland: energy advisers, designers, and certified auditors. Romania: certified auditors, engineering designers, and contractors. Slovenia: cultural heritage authority (ZVKDS), energy auditors, and contractors.	Capacity shortages: severe shortages of specialized technical and contractor capacity during peak market activity, especially for heritage buildings. Cost and quality volatility: high inflation in labour/material costs, coupled with poor-quality or incomplete project design documentation. Heritage friction: strict preservation restrictions on facades, colours, and materials clash with standard envelope insulation protocols.	Early-stage heritage coordination: initiate formal technical coordination with heritage authorities during the <i>concept design stage</i> to align materials and colours before final procurement. Technical QA protocols: introduce strict, mandatory quality-control inspections and continuous, post-renovation environmental and energy-use verification. Simplified technical templates: simplify and standardise technical designs and bills of quantities for typical precast/ prefabricated MAB typologies to reduce designer overhead.

6. Practical findings

The adopted methodology shifted the focus from purely technical metrics to a holistic, human-centric "value proposition."

- **The non-financial multiplier:** energy-cost savings alone rarely justify massive CapEx. The strategic argument must emphasize the elimination of mold, the prevention of heatwave-related health risks, and the preservation of building durability.
- **The electricity consumption bounce:** a critical finding from Estonian and Polish pilots is that deep renovation cuts thermal demand by 40–60% but *increases*

electricity consumption due to MVHR, automation, and lifts. Consequently, rooftop and balcony PV systems are essential compensatory measures, not optional additions.

- **The homeowners' associations approval model:** the most effective catalyst for homeowners' associations approval in vulnerable districts (Alba Iulia example) is for the municipality to absorb the 2% co-financing rate and all non-eligible expenses. This removes the immediate financial barrier for those earning €300–€500 per month.

7. Cross-regional energy & climate performance synthesis

Aggregated data is a powerful tool for benchmarking regional performance and tracking the collective progress toward EU-level climate goals.

The table below synthesizes the impact across all pilot Multi-Apartment Buildings that were included in the 5 regional roadmaps:

Regional indicator (aggregated)	Unit	Croatia	Estonia	Slovenia	Romania	Poland
Number of MABs included in the roadmap (to be renovated)		6	6	6	6	6
Baseline final energy consumption before renovation (sum)	GWh/yr	-	3,334	1,201	6,541	5,667
Final energy savings after renovation (sum)	GWh/yr	0.900	1,107	0.207	2,697	1,239
Primary energy savings after renovation (sum)	GWh/yr	1,210	1,454	0.227	3,506	0.694
Estimated CO₂ reduction after renovation (sum)	tCO ₂ /yr	2,268	78,204	68,860	555	69,791
Energy Performance Certificate class improvement (average)	class diff.	2.8	1.8	-	1.3	-
Renewable energy potential (sum)	GWh/yr	-	0.036	0	0.900	0.118
Expected reduction of heating demand (average)	%	-	46,595	26,000	40,440	21,870

The following findings detail the multi-regional technical and environmental outcomes of the planned building renovations based on the impact synthesis in the 5 regional roadmaps.

Aggregate multi-regional savings & energy intensity profiles

Across the five participating pilot regions, the planned building renovations represent a major reduction in regional energy footprints. In aggregate, it is projected to deliver 6.15 GWh/year of final energy savings and 7.09 GWh/year of primary energy savings. Looking more closely at national data, the final energy savings in Romania's pilot region

represent more than 43% of the total (2.697 GWh/year) and nearly 50% of the total primary energy savings (3.506 GWh/year) across its unrenovated, communist-era blocks. Estonia (Tartu pilot region) yields 1.107 GWh/year in final energy savings, it achieves the highest relative energy intensity reduction, boasting an exceptional 46.595% average reduction in heating demand. This is followed closely by Romania's 40.44%, heating demand whereas Slovenia (Ptuj & Kidričevo pilot regions) represents the most conservative savings intensity with 26.0% heating demand - a reflection of its smaller building scale and strict heritage constraints that limit the thickness of insulation.

The carbon mitigation paradox & the electricity consumption bounce

A critical synthesis of the carbon dioxide performance indicators reveals a technical paradox between Romania and Estonia. Romania achieves a carbon mitigation of 555.00 tCO₂/year. Estonia displays a net *increase* in greenhouse gas emissions post-renovation, registering a CO₂ mitigation of 78.204 tCO₂/year. This indicator illustrates the "electricity consumption bounce" observed in the Tartu pilot. While comprehensive insulation measures drastically cut space-heating demands by nearly half, the introduction of modern, automated mechanical ventilation with heat recovery (MVHR) systems significantly increases the building's baseline electricity consumption. Because the local Estonian electricity grid has a high carbon emission factor, this electric load increase temporarily outpaces the carbon savings of the thermal envelope retrofits, highlighting why the integration of local renewables is a non-negotiable component of deep decarbonisation.

Renewable energy integration and regional constraints

To offset the post-renovation electricity surge, the deployment of local Renewable Energy Sources varies extensively by country. Romania has mapped a potential 0.900 GWh/year of renewable electricity (primarily through extensive rooftop and balcony solar PV systems), which directly supports its high carbon savings. Poland planned 0.118 GWh/year of localized solar PV electricity production to power elevator services and common-area ventilation, while Estonia incorporates a more localized 0.036 GWh/year of PV solar potential. Slovenia registers 0 GWh/year in renewable potential, also due to severe structural limitations on aging roofs and strict preservation guidelines from the Cultural Heritage Authority (ZVKDS) that restrict the placement of PV arrays in historic districts. Croatia's building summaries highlight that localized PV, battery storage, and heat pumps are strongly recommended as secondary measures to achieve long-term carbon neutrality.

Depth of renovation reflected in Energy Performance Certificate class transitions

The technical depth of the planned interventions is clearly illustrated by the average class improvements. Croatia (Čakovec) leads the multi-regional cohort with an average improvement of 2.8 class steps. This transition is exemplified by buildings like *Vladimira Nazora 32*, which successfully transitions from a class D/E baseline to a highly efficient class B/A+ rating. Estonia follows with an average improvement of 1.8 classes (moving its ready-stage buildings towards national grant eligibility thresholds), while Romania averages a 1.3 class EPC improvement across its larger, uninsulated residential blocks.

8. Strategic recommendations

To transition from pilot "islands" to systemic regional scaling, the following strategic shifts are recommended:

Socio-economic prioritisation

Municipalities should utilize digital tools, such as the **R Studio matrix**, to rank buildings for investment. By tracking income levels, unemployment, and space-heating costs, authorities can ensure that the most vulnerable districts—those at highest risk of becoming stranded assets—are addressed first.

Funding and finance policy

The "first-come, first-served" grant model is inefficient. Funding should transition toward vulnerability-based criteria, supported by state-guaranteed loans and Energy Service Company frameworks to reduce the reliance on 100% public grants.

Homeowners' associations consensus and property uplift

To secure legal voting majorities, the value proposition for homeowners must highlight the property value increase identified in the pilots. The significant net equity gain (e.g., often outweighs the immediate concerns regarding renovation disruption).

Operationalising support services

The creation of permanent One-Stop-Shops is very important. These centres provide the continuous technical and legal guidance homeowners' associations need to navigate the complex renovation process from initial audit to final implementation.

9. Conclusion

The CEESEN-BENDER roadmaps have developed a credible guide towards ensuring an equitable energy transition. The use of both technical and social considerations and the focus on non-financial multipliers such as health and property values makes sure that those who need help the most in Central and Eastern Europe are at the centre of the 2050 climate-neutral transition.



Co-funded by
the European Union

The CEESEN-BENDER project has received funding from the European Union's Programme for the Environment and Climate Action (LIFE 2021-2027) under grant agreement no LIFE 101120994. The information and views set out in this material are those of the author(s) and do not necessarily reflect the official opinion of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.



CEESEN-BENDER

**Building intErventions in vulNerable Districts against
Energy poveRty**

Deliverable 5.3

**Report on building – level renovation roadmaps in 5
pilot regions**

**Renovation roadmaps and investment strategies for
buildings in the pilot region Medjimurje County
(Croatia)**

- Summary -

Dissemination Level: Public

WP5 Creating roadmaps and support services for building energy renovations for vulnerable districts

Čakovec, 2026



**Co-funded by
the European Union**



**CENTRAL & EASTERN EUROPEAN
SUSTAINABLE ENERGY NETWORK
CEESEN-BENDER**

Building – level renovation roadmaps and investment strategies for pilot multiapartment buildings in Medjimurje County (Croatia)

The **CEESEN-BENDER project – Building Interventions in Vulnerable Districts against Energy Poverty** aims to empower and support vulnerable apartment owners and tenants living in multiapartment buildings constructed in the period between the Second World War and the 1990s. The project is implemented in 6 Central and Eastern European countries: Croatia, Estonia, Germany, Poland, Romania and Slovenia, whereby the Croatian region Medjimurje County has been selected as one of the pilot sites for the implementation of the various project activities. The Croatian deliverable **D5.3 Report on building – level renovation roadmaps in 5 pilot regions** focuses on the pilot region Medjimurje County and provides building – level renovation roadmaps and investment strategies for 6 multiapartment buildings in the town of Čakovec, out of which 5 are unrenovated and 1 has been partially renovated during the project duration.

The buildings represent a typical multiapartment housing stock in Medjimurje County, constructed during the second half of the 20th century, whereby the 6 selected pilot buildings have the same or similar characteristics and share common challenges related to the condition of the envelopes, technical systems and ventilation, as well as integration of renewable energy sources (RES). The buildings are predominantly privately owned and managed by the 2 main building managers operating in the area, GP Stanorad Ltd. and Euroland Ltd.

The field activities carried out within the project CEESEN-BENDER provided an evidence base for the development of the planned roadmaps and investment strategies. The implemented project activities included the analysis of the 6 selected pilot buildings, organisation of 9 workshops and Q&A sessions for building managers, landlords, homeowners and tenants, monitoring of the indoor air quality in 7 buildings and 12 apartments, as well as conducted 400 surveys and 7 expert group visits to energy poor households.

Furthermore, energy poverty remains an important structural challenge in the renovation of multiapartment buildings. Vulnerable households may face difficulties participating in renovation projects because the required co – financing can represent a significant financial burden for them. The project, therefore, emphasises the importance of involving social care institutions and building managers capable of identifying, communicating with and supporting vulnerable households throughout the renovation process. Following the mentioned, the energy renovation implies a broad network of stakeholders, including building managers, homeowners and tenants, technical staff, regional and local authorities, energy agencies and financial institutions, as well as fosters a timely, open and quality communication and cooperation in order to achieve the set goals and ensure long lasting benefits.

Stakeholder classification

The renovation of multiapartment buildings in Medjimurje County involves a broad network of stakeholders with complementary roles in planning, financing and

implementation. The main stakeholder groups, their roles, identified barriers and recommended actions are summarised below.

Stakeholder name/group	Specific role in building renovation	Main barriers encountered	Recommended actions
Building managers – GP Stanorad Ltd. and Euroland Ltd.	Coordinate the renovation process, collect documentation, prepare and submit applications, collect offers, coordinate technical staff and contractors, communicate with residents and financial institutions, and manage payments and reimbursement procedures.	Administrative complexity, need for extensive documentation, availability of financing, communication with residents and coordination of multiple stakeholders.	Strengthen project-management capacities, involve technical experts at an early stage, improve communication with residents, and provide systematic support for preparation and submission of renovation projects.
Homeowners, tenants and tenant representatives	Participate in decision-making, communicate residents' interests, contribute to co-financing and support planning and implementation of renovation measures.	High co-financing requirements, different levels of awareness and involvement, limited knowledge of available financing opportunities and renovation procedures.	Improve access to information and advice, involve residents from the early planning stages, and provide targeted financial and advisory support for vulnerable households.
Technical staff – architects, designers, energy experts and contractors	Prepare technical documentation, design renovation measures, carry out works and ensure compliance with technical and energy-performance requirements.	Poor-quality or incomplete project documentation, insufficient cost estimates, rising construction and labour costs, and quality-control challenges.	Engage qualified technical staff early, improve the quality of project documentation and cost estimates, and introduce regular quality control during implementation.
Financial institutions and banks	Provide loans and other financial instruments to cover homeowners' own contribution and renovation costs.	High investment costs, limited capacity of households to provide own financing, and	Develop accessible green loans and financing products for multiapartment buildings and improve coordination between public

Stakeholder name/group	Specific role in building renovation	Main barriers encountered	Recommended actions
		relatively long payback periods.	grants and bank financing.
National authorities and public funding institutions	Establish the regulatory and financing framework and provide public co-financing through renovation programmes and calls.	Limited availability and frequency of public calls, insufficient funding compared with demand, and limited targeting of energy-poor households in multiapartment buildings.	Increase the scale and frequency of renovation programmes, expand support for multiapartment buildings, and introduce targeted support for vulnerable households.
Regional and local authorities	Support the development of regional and local energy and climate policies and may provide financial or organisational support for renovation.	Limited availability of programmes specifically targeting energy renovation of multiapartment buildings.	Establish regional/local support programmes and integrate building renovation and energy-poverty objectives into local and regional policies.
Energy agencies – MENEAs	Provide information, education, advisory and consultancy services, support project preparation and implementation, and facilitate communication between stakeholders and funding institutions.	Need for stronger coordination and accessible information on financing and renovation procedures.	Strengthen advisory services and develop integrated One-Stop-Shop services providing technical, financial and administrative support.
Social care institutions	Support the identification, communication with and engagement of vulnerable and energy-poor households.	Lack of systematic information on energy poverty and limited mechanisms for targeting vulnerable households within building renovation programmes.	Strengthen cooperation with building managers and energy agencies and establish mechanisms for identifying and supporting energy-poor households during renovation.

One of the main barriers are, also, the financing opportunities for multiapartment buildings. The Croatian financing framework includes national public calls provided by the the National Recovery and Resilience Plan (NPOO) as the main source of co – funding, while the Operational Programme Competitiveness and Cohesion (OPCC), National Housing Policy of the Republic of Croatia and European programmes such as Interreg, LIFE and HORIZON are not widely used for renovation investments. Additional financing can be provided in the form of savings from homeowners and commercial bank loans, while national development banks can provide interest rate support.

As mentioned, the roadmaps and investment strategies focus on the following 6 selected pilot buildings in Medijmurje County: Vladimira Nazora 32, Čakovec; Travnik 12, Čakovec; Istarska 16, Čakovec; Josipa Jurja Strossmayera 7b, Čakovec; Janka Slogara 4, Čakovec and Istarska 14, Čakovec.

Energy performance synthesis

The six pilot buildings show a significant potential for energy and emission savings through the proposed renovation measures. The available building-level assessments estimate total annual savings of approximately **1.21 GWh of primary energy and 0.90 GWh of final energy**, together with an estimated reduction of approximately **217.69–253.18 tCO₂ per year**, depending on the calculation methodology and emission factors applied.

Pilot building	Baseline energy performance / EPC	Expected primary energy savings (GWh/year)	Expected final energy savings (GWh/year)	CO ₂ reduction (tCO ₂ /year)	Expected EPC after renovation	RES measures planned
Vladimira Nazora 32	EPC class D; building already partially renovated	0.20467	0.13511	33.68 / 42.78	B/A+ (achieved)	PV, battery, heat pump – recommended additional measures
Travnik 12	EPC class E	0.11297	0.08577	20.62 / 23.61	C or higher	PV and other RES measures recommended
Istarska 16	EPC class E	0.20465	0.15551	37.38 / 42.77	B or higher	PV, battery, heat pump
Josipa Jurja Strossmayera 7b	EPC class E	0.33449	0.24616	59.65 / 69.91	B or higher	PV, battery, heat pump
Janka Slogara 4	EPC class F	0.10348	0.07901	18.97 / 21.63	Not explicitly quantified in the roadmap	PV and battery

Pilot building	Baseline energy performance / EPC	Expected primary energy savings (GWh/year)	Expected final energy savings (GWh/year)	CO2 reduction (tCO2/year)	Expected EPC after renovation	RES measures planned
Istarska 14	EPC classes E and G	0.25109	0.19921	47.39 / 52.48	C or higher	PV, battery, heat pump

Taking into consideration the similar construction and technical characteristics, as well as the overall renovation practices in Medjmurje County, recommended interventions in the mentioned buildings include thermal insulation of the external walls, roofs and basement ceilings, replacement of the carpentry and technical systems (mainly heating/cooling and preparation of domestic hot water), installation of RES based systems such as PV panels, heat pumps and energy storage, improvement of the indoor air quality through automatic ventilation and heat recovery systems, as well as air quality monitoring, smaller energy management measures and actions aimed at improving the indoor comfort. Apart from the technical measures, the roadmaps and investment strategies present, also, energy savings and financial estimates calculated using the currently available consumption data, energy saving regulations and recommendations valid in the Republic of Croatia, energy costs currently available on the market and digital tools developed within the project CEESEN-BENDER.

At policy level, the Croatian pilot findings indicate the need to increase the scale and frequency of energy renovation programmes for multiapartment buildings, improve access to information through integrated One-Stop-Shop services, strengthen financial support for energy poor households and expand support mechanisms from individual family houses to multiapartment buildings. The roadmaps, also, recommend programmes specifically targeting energy poor households in multiapartment buildings, including identification, support in co – financing and continued advice on reducing energy consumption and costs.

Finally, the documents provide added value by translating general national and regional renovation objectives into concrete investment proposals for different buildings. They combine technical information, energy saving potential, CO₂ reduction estimates, indoor air quality observations, financing opportunities and stakeholder considerations in a single planning framework. In this way, the 6 selected pilot buildings are considered to be practical examples, that can support future renovation planning in Medjmurje County and serve as basis for replicating the results and approach of the project CEESEN-BENDER in other renovation projects, as well as Croatian regions.



Co-funded by
the European Union

The CEESEN-BENDER project has received funding from the European Union's Programme for the Environment and Climate Action (LIFE 2021-2027) under grant agreement no LIFE 101120994. The information and views set out in this material are those of the author(s) and do not necessarily reflect the official opinion of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.



CEESEN-BENDER

**Building intErventions in vulNerable Districts against
Energy poveRty**

Deliverable 5.3

**Report on building – level renovation roadmaps in 5
pilot regions**

**Renovation roadmaps and investment strategies for
buildings in the pilot region Tartu pilot area**

(Estonia)

- Summary -

Dissemination Level: Public

WP5 Creating roadmaps and support services for building energy renovations for vulnerable districts

Tartu, 2026



**Co-funded by
the European Union**



**CENTRAL & EASTERN EUROPEAN
SUSTAINABLE ENERGY NETWORK
CEESEN-BENDER**

Building – level renovation roadmaps and investment strategies for pilot multiapartment buildings in Tartu pilot area (Estonia)

As part of the CEESEN-BENDER project, building-specific renovation roadmaps were prepared for six multi-apartment buildings in the Tartu pilot area (Karlova and Annelinn districts). The roadmaps are intended to support apartment associations, homeowners, building managers and other relevant stakeholders in understanding the current condition of the buildings, identifying renovation needs and planning the next steps towards improved energy efficiency, indoor climate and overall building quality.

The roadmaps were developed using available technical documentation, energy performance data, indoor climate measurements, home visits, stakeholder consultations, expert assessments and, where available, completed renovation designs, energy calculations and preliminary contractor quotations. They are not intended to replace the underlying technical documentation, which remains available to apartment associations for the technical preparation and implementation of renovation. Instead, the roadmaps extract and explain the information most relevant for homeowners and present it in a concise and understandable form to support decision-making.

The six pilot buildings were at very different stages of renovation readiness. It would therefore not have been appropriate to apply the same level of detail to every building. The content and level of detail of each roadmap were adapted to the stage reached by the building and to the decisions facing the respective apartment association.

Roadmaps for buildings at the investment preparation stage

Four buildings (Jaama 77, Uus 63a, Anne 45 and Pikk 84) progressed to an advanced stage of renovation preparation during the project period. Their apartment associations moved towards comprehensive renovation and the national renovation grant application process, supported by different CEESEN-BENDER activities during this period. Detailed renovation designs and energy calculations were prepared, and all four buildings reached the renovation grant application stage. Two of the buildings received grant support and moved into procurement and final technical preparation for renovation works, while the other two did not receive support in that funding round and remained dependent on future funding opportunities.

For these buildings, the roadmaps mainly support investment decisions. They bring together information on:

- the current technical condition and energy performance of the building;
- the main technical problems and renovation needs;
- planned comprehensive renovation measures;
- expected changes in energy use and indoor climate;
- estimated investment costs and financing needs;

- expected effects on operating costs;
- the current implementation status; and
- the remaining decisions and actions required before construction.

The assessment of these buildings showed that comprehensive renovation can substantially reduce heating demand while at the same time increasing electricity consumption. This is mainly due to the introduction of mechanical ventilation with heat recovery, automation and other modern technical systems, as well as the electrification of some existing uses.

Renovation should therefore not be assessed only in terms of heating savings. Changes in total final energy demand, electricity consumption, indoor climate, technical condition and operating costs need to be considered together.

The financial assessment also showed that energy-cost savings alone do not necessarily compensate for the investment and loan payments. In some cases, the annual energy bill may remain relatively similar even after a substantial improvement in energy performance. The main benefits of renovation therefore also include improved indoor climate, better technical condition, reduced risk of failures and emergency repairs, longer building lifetime and improved long-term usability and value.

The experience of these four buildings also showed that technical readiness does not automatically lead to implementation. Even where technical designs and energy calculations have been completed, implementation remains dependent on the availability of renovation grants, financing conditions, construction prices and the final investment decision of the apartment association. In Estonia, eligibility for the national apartment-building renovation grant is tied to comprehensive renovation and is therefore a major factor in apartment associations' decisions on whether and when to proceed. Predictable and continuous support schemes are important for turning technically prepared projects into actual renovation works.

Roadmaps for buildings at the preparatory stage

Two buildings remained at an earlier stage of renovation preparation during the project period: a five-storey prefabricated concrete apartment building in Annelinn (Pikk 94) and a small two-storey wooden apartment building in Karlova (Väike-Tähe 7). When the 2025 renovation grant round opened, these buildings had not yet reached the stage where a grant application could realistically be prepared. Their roadmaps therefore focused on identifying the most appropriate renovation pathway and the next steps needed to move the renovation process forward. In practice, they:

- describe the current technical and energy situation;
- identify the most important problems and potential improvement areas;
- integrate available findings from measurements, home visits and consultations;
- identify missing information and further studies required;
- outline possible future renovation pathways; and
- define practical next steps towards a future renovation decision.

For the Annelinn building, information from different project activities helped to build a more complete picture of the renovation needs. Although several building systems

have already been improved, the building still has significant heat losses through the envelope and does not have modern heat-recovery ventilation. Indoor climate measurements also identified periods of insufficient ventilation and elevated CO₂ concentrations. Energy performance indicators alone therefore do not provide a complete picture of renovation needs, and the indoor climate measurements revealed additional issues that should be considered in future renovation planning.

The situation of the Karlova building is different. The small wooden apartment building has already improved its energy performance following the renovation of the heating system and connection to district heating, but no comprehensive renovation project has been prepared. Because of its small size, previous investments and location in a heritage/environmentally valuable area, the appropriate next step is not necessarily to proceed immediately with a standard comprehensive renovation package. Instead, more detailed assessment of the building envelope, ventilation, technical condition and apartment association readiness is needed before selecting the most appropriate long-term renovation pathway.

Key lessons learned

Based on the experience of preparing the six roadmaps, the main lessons learned were:

- **Building-level roadmaps should reflect renovation readiness.** The purpose and level of detail of a roadmap should depend on how far the building has progressed in the renovation process. For buildings that have reached the technical design and financing preparation stage, the roadmap can support the investment decision, while for buildings at an earlier stage it should primarily identify information gaps and establish the next steps.
- **Renovation benefits extend beyond direct energy-cost savings.** Improved indoor climate, building safety and technical reliability, reduced maintenance risks and longer building lifetime can be equally important factors in the investment decision.
- **Energy use should be assessed together with indoor climate.** Comprehensive renovation generally reduces heat demand, while electricity consumption may increase because ventilation, automation and other technical systems are introduced to provide an indoor climate that may not have been adequately ensured before renovation. Measurements of CO₂, temperature and humidity also showed that energy consumption alone does not reveal whether adequate indoor conditions are being maintained.
- **Financing remains one of the decisive factors for implementation.** Even technically well-prepared renovation projects may not proceed to construction if grant support is unavailable or financing conditions are unsuitable. Technical preparation alone therefore does not guarantee implementation.
- **Renewable energy solutions need to be assessed building by building.** Rooftop PV can help compensate for increased electricity consumption after renovation, but its feasibility and relevance depend on available roof area, competing

technical equipment, structural conditions, investment costs and expected self-consumption.

- **Renovation pathways need to be adapted to the individual building.** Building size, construction type, technical condition, previous investments and heritage requirements can all affect which renovation measures are appropriate and in what sequence they should be implemented.
- **Roadmaps should interpret technical information rather than duplicate it.** The technical documentation required for renovation, including designs, energy calculations and other assessments, is prepared separately as part of the renovation process and, where relevant, the grant application process. The roadmap does not replace these documents; its added value is to extract the most relevant findings and explain in clear terms what they mean for the building, the planned renovation and the decisions facing homeowners.

Overall conclusion

The experience with the six Tartu buildings showed that building-level roadmaps can serve two different purposes. For buildings that progressed to an advanced stage of renovation preparation, the roadmap brings together and interprets the relevant technical, energy and financial information in a form that supports investment decisions by apartment associations and homeowners. For buildings at an earlier stage, it helps to structure the pathway towards renovation by identifying the main issues, further assessments and practical next steps.

The Estonian experience suggests that a useful building-level roadmap can follow a common underlying structure, while its focus and level of detail should reflect the building's stage in the renovation process and the decisions that need to be made. Its added value is not to replace the technical documentation required for renovation, but to make the relevant information understandable and useful as practical decision support for homeowners.



Co-funded by
the European Union

The CEESEN-BENDER project has received funding from the European Union's Programme for the Environment and Climate Action (LIFE 2021-2027) under grant agreement no LIFE 101120994. The information and views set out in this material are those of the author(s) and do not necessarily reflect the official opinion of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.



CEESEN-BENDER

**Building intErventions in vulNerable Districts against
Energy poveRty**

Deliverable 5.3

**Report on building – level renovation roadmaps in 5
pilot regions**

**Renovation roadmaps and investment strategies for
buildings in the pilot region Kidričevo and Ptuj pilot areas**

(Slovenia)

- Summary -

Dissemination Level: Public

WP5 Creating roadmaps and support services for building energy renovations for vulnerable districts

2026



**Co-funded by
the European Union**



**CENTRAL & EASTERN EUROPEAN
SUSTAINABLE ENERGY NETWORK
CEESEN-BENDER**

Building – level renovation roadmaps and investment strategies for pilot multiapartment buildings in Kidričevo and Ptuj pilot areas (Slovenia)

As part of the CEESEN-BENDER project, building-level renovation roadmaps were prepared for six multi-apartment buildings located in the Slovenian pilot area of Kidričevo and Ptuj. Four buildings are located in Kidričevo and two in Ptuj. All six buildings are connected to district heating and represent older multi-apartment housing stock with remaining needs for energy renovation, improved comfort and reduced exposure to energy poverty.

The roadmaps are intended to support building managers, apartment owners, residents, municipalities, local energy advisors and other relevant stakeholders in preparing future renovation activities. They provide a practical basis for understanding the current condition of the buildings, identifying priority renovation measures, estimating investment needs and planning the next steps towards implementation.

The Slovenian roadmaps were prepared on the basis of available building data, Task 4.1 energy-consumption information, technical documentation where available, household-visit findings, national CEESEN-BENDER reports on regulatory, technical and economic barriers, and the CEESEN-BENDER Renovation ROI Calculator Tool. The level of technical detail differs between buildings, depending on the availability of building-specific documentation. For some buildings, renovation measures are based on more concrete technical documentation, while for others the roadmap provides planning-level estimates and identifies the need for further technical verification.

Main findings

1. Façade and building-envelope renovation are the main priorities

The main renovation priority across the Slovenian pilot buildings is the improvement of the building envelope, especially façade and external-wall insulation. Depending on the building, this may also include plinth and basement-zone insulation, attic or roof insulation, basement-ceiling insulation, treatment of window reveals, adaptation of external sills and downpipes, and fire-safety details.

In Kidričevo, façade renovation must also take into account cultural heritage requirements. This means that materials, façade colours, plaster structure, insulation thickness, balcony details and other visible elements may need to be coordinated with the Institute for the Protection of Cultural Heritage of Slovenia. These requirements can influence both the technical solution and the investment cost.

2. Energy poverty and comfort are central issues

The roadmaps do not treat renovation only as a technical or financial investment. They also address energy poverty, indoor comfort and living conditions. Household visits carried out in Kidričevo confirmed problems such as high heating costs, mould risk, cold surfaces, thermal bridges and summer overheating in similar unrenovated buildings.

These findings show that building-level measures are necessary, because household-level advice alone cannot solve problems caused by uninsulated façades, attics, cellar ceilings or poor building-envelope performance.

The roadmaps therefore link energy renovation with wider benefits, including better winter comfort, reduced mould risk, lower exposure to heating-cost increases, improved summer resilience, better protection of the building structure and improved living conditions for vulnerable households.

3. Investment planning must remain realistic and building-specific

The total indicative investment estimate for the six Slovenian pilot buildings is approximately EUR 2.05 million. The expected final energy saving is estimated at approximately 206.5 MWh/year, corresponding to a weighted average heat-saving assumption of around 26% across the six buildings. These values are planning-level estimates and should be updated once final technical documentation, bills of quantities, tenders and/or building-specific energy-audit calculations are available.

The investment values differ between buildings because the available documentation and technical complexity differ. For example, some Kidričevo buildings require heritage-sensitive renovation details, while the two Ptuj buildings use a neighbouring Ptuj PZI as an indicative technical reference only.

4. ROI results confirm the long-term character of envelope renovation

The CEESEN-BENDER Renovation ROI Calculator Tool was used as an additional planning tool for all six Slovenian pilot buildings. The calculated simple payback periods are relatively long, which is expected for façade and building-envelope renovation. The ROI results therefore need to be interpreted carefully.

Unlike photovoltaic investments, envelope renovation does not generate quick financial returns only through energy-cost savings. Its value also lies in comfort, health, durability, reduced mould risk, improved building protection and reduced energy-poverty exposure. For this reason, the roadmaps present ROI as one part of the decision-making process, not as the only criterion for renovation.

Building observations

1. Kajuhova ulica 11, Kidričevo

Kajuhova ulica 11 is the largest Slovenian pilot building, with 51 apartments. No building-specific PZI documentation was available, so the roadmap provides a planning-level renovation approach. The main proposed measure is façade and external-wall insulation with complementary checks of the roof/attic, basement ceiling, windows, doors and district-heating regulation. Because the building is located in Kidričevo, heritage requirements and affordability for residents must be considered before implementation.

2. Čučkova ulica 7, Kidričevo

Čučkova ulica 7 is a smaller multi-apartment building with four apartments. The roadmap provides a more detailed envelope-renovation package, including façade insulation, plinth/basement-wall insulation, attic-floor insulation, basement-ceiling insulation, fire-safety details and façade accessories. The building is relevant for demonstrating how a smaller heritage-sensitive building in Kidričevo can be prepared for renovation while addressing comfort, heat losses and affordability.

3. Ulica Borisa Kraigherja 8, 10, 12, Kidričevo

This building replaces the earlier BK 7, 9, 11 pilot building and is supported by more concrete technical documentation. The proposed package includes graphite EPS façade insulation, XPS plinth insulation, attic and basement-ceiling measures and fire-safety details. Due to the heritage context of Kidričevo, the renovation must be coordinated with ZVKDS. The investment value is relatively high, reflecting the technical and heritage-related complexity of the works.

4. Ulica Borisa Kraigherja 20, 22, 24, 26, Kidričevo

For this building, the roadmap uses an older PZI/cost basis and updates it to reflect the current assumption of 13 cm graphite EPS façade insulation and present market conditions. The roadmap recommends updating the technical description, quantities and cost estimate before implementation. Available energy-audit or updated calculation results should be used to confirm the expected savings.

5. Ulica 25. maja 7, 9, Ptuj

For Ulica 25. maja 7, 9, the main proposed measure is façade/external-wall insulation. The technical and material assumptions are based on a neighbouring Ptuj PZI for Ulica 5. prekomorske 9 and must be adapted to the actual building before implementation. The roadmap therefore treats the current investment and ROI values as indicative planning-level estimates.

6. Arbajterjeva ulica 3, Ptuj

Arbajterjeva ulica 3 is also treated as a façade-focused renovation case. As with Ulica 25. maja 7, 9, the neighbouring Ptuj PZI is used only as a technical reference. Before implementation, the actual façade build-up, previous insulation, roof/attic condition, window details, fire-safety requirements and heating settings should be verified through building-specific technical documentation.

Common recommendations and overall conclusions

Based on the six Slovenian building-level roadmaps, the following actions are recommended:

- validate the indicative investment values through final PZI documentation, bills of quantities and tenders;
- confirm energy-saving values through building-specific energy audits or simulations;

- coordinate heritage requirements early for the Kidričevo buildings;
- prepare financing scenarios using Eco Fund support, loans, reserve funds and possible additional support for vulnerable households;
- communicate renovation benefits clearly to apartment owners and residents, including both financial and non-financial benefits;
- monitor heat use, costs, comfort, moisture risk, overheating and resident satisfaction after renovation;
- consider complementary future measures such as ventilation improvements, renewable energy integration, passive shading and accessibility improvements where technically and financially feasible.

Overall, the Slovenian roadmaps demonstrate that building-level renovation planning must combine technical, financial and social aspects. The main investment focus is façade and building-envelope renovation, but the expected benefits go beyond energy savings. The roadmaps support a staged and realistic renovation pathway that can improve energy efficiency, indoor comfort, affordability and resilience, while helping local actors in Kidričevo and Ptuj move from problem identification towards concrete renovation planning and future implementation.



The CEESEN-BENDER project has received funding from the European Union's Programme for the Environment and Climate Action (LIFE 2021-2027) under grant agreement no LIFE 101120994. The information and views set out in this material are those of the author(s) and do not necessarily reflect the official opinion of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.



CEESEN-BENDER

**Building intErventions in vulNerable Districts against
Energy poveRty**

Deliverable 5.3

**Report on building – level renovation roadmaps in 5
pilot regions**

**Renovation roadmaps and investment strategies for
buildings in the pilot region Alba Iulia (Romania)**

- Summary -

Dissemination Level: Public

WP5 Creating roadmaps and support services for building energy renovations for vulnerable districts

Alba Iulia, July 2026



**Co-funded by
the European Union**



**CENTRAL & EASTERN EUROPEAN
SUSTAINABLE ENERGY NETWORK
CEESEN-BENDER**

Building – level renovation roadmaps and investment strategies for pilot multiapartment buildings in Alba Iulia (Romania)

The residential building stock in Alba Iulia municipality, as across the rest of Romania, is heavily dominated by multi-apartment buildings (MABs) constructed during the communist era, primarily between 1960 and 1980, using precast reinforced concrete panels or structural brick masonry. These buildings exhibit severe systemic technical deficiencies, including an acute absence of thermal insulation on external walls, uninsulated basements and roofs, single-glazed wooden windows with deteriorated frames, and obsolete space heating and hot water distribution systems. Consequently, the majority of targeted MABs fall into energy performance classes C or D, presenting massive heat losses and specific annual space heating consumption levels ranging between 171.74 and 292.17 kWh/m² per year. Executing deep energy renovations on these structures holds massive potential, as comprehensive interventions can decrease space heating energy demand by 40% to 60% per building, contributing directly to climate neutrality targets and enhanced living standards.

Field evaluations and home visits conducted under the CEESEN-BENDER project in pilot areas across Alba Iulia, including Cloșca, Alexandru Ioan Cuza, Livezii, Transilvaniei, and Gheorghe Șincai streets, revealed severe indoor living condition challenges in unrenovated apartments. Ground-floor residents endure major heat losses through uninsulated basement ceilings, leaving indoor ambient temperatures in bathrooms well below comfort thresholds during winter. Conversely, uninsulated upper-floor and south-facing apartments suffer from severe summer overheating, reaching temperatures around 30°C and drastically reducing living quality without air conditioning. The lack of facade insulation, combined with balcony thermal bridges and poor ventilation, frequently causes condensation and mold growth on external walls during winter. Furthermore, 12-month continuous indoor air quality monitoring using ALEA HomeMonitor devices demonstrated that carbon dioxide (CO₂) concentrations rise alarmingly at night in unventilated bedrooms, reaching peaks between 2,000 ppm and 5,000 ppm when windows remain closed. This proves that simple facade insulation and window replacements are insufficient, making the integration of mechanical ventilation systems with heat recovery (MVHR) indispensable for maintaining healthy indoor air quality and preventing mold.

Energy poverty represents a major structural challenge in Alba Iulia, where data collected at the level of homeowners' associations indicates that between 30% and 60% of residents in target buildings are vulnerable or at high risk of energy poverty. This population is predominantly composed of low-income households, elderly retirees, single-person households, and citizens with chronic illnesses or disabilities. Average net monthly household incomes for vulnerable families range between 300 and 500 EUR, while utility costs consume between 20% and 40% of this income. Under this unbearable financial pressure, many residents resort to intentional self-disconnection by turning off

heating during winter, a survival mechanism that damages building structures through mold growth and severely deteriorates public health. Sociological surveys from the project demonstrate that while renovation drastically reduces structural defects and improves perceived thermal comfort, it does not automatically resolve financial payment difficulties, as utility bill arrears occasionally persist post-renovation due to broader macroeconomic factors, energy prices, and user behaviors. Furthermore, resident concerns post-renovation shift from the building envelope toward common area infrastructure, such as elevators, drainage, and stairwell maintenance.

The deep energy renovation of communist-era MABs involves a complex network of stakeholders across national, regional, and local levels whose coordination determines project success. At the national level, the Ministry of Development, Public Works and Administration (MDLPA) establishes construction and energy efficiency policies and supervises national building renovation programs. Concurrently, the Ministry of Investments and European Projects (MIPE) serves as the managing authority for the National Recovery and Resilience Plan (PNRR), administering essential grant funding for MAB renovations. At the regional level, the Agency for Regional Development Center (ADR Centru) manages structural funds allocated through the European Regional Development Fund (ERDF), specifically the Regional Program Center (PRC) 2021-2027 Action 3.1, allocating non-reimbursable funds and monitoring territorial implementation. At the local operational level, the Municipality of Alba Iulia acts as project applicant and coordinator, managing public procurement, building permits, and site supervision, while the Alba Local Energy Agency (ALEA) provides technical advisory services, baseline energy data, air quality monitoring, and home visits. Finally, homeowners associations (HOAs) and individual apartment owners represent the demand side; because 100% of apartments in Romanian MABs are privately owned, securing a legal majority or two-thirds consensus among residents is mandatory to initiate renovation works.

Classification table of stakeholders involved in the renovation of multiapartment buildings in Alba Iulia (Romania):

STK Name/ Group	Main role(s) in MAB renovation	Main barrier(s) in MAB renovation in pilot area	Recommended action(s) for barrier(s) overcoming
Alba Iulia Municipality	Applicant / facilitator	Insufficient public funds for MAB energy renovation, limited knowledge / capacity on MABs energy renovation, high bureaucracy of MABs renovation projects /	Increase the use of private funds / set-up a municipal company dedicated to MABs energy renovation / improve staff capacity / support reduced bureaucracy of local MABs energy renovation projects / tender books optimised for

		long public procurement process	efficient delivery of MAB energy renovation works
Regional Development Agency	Financier and funds / grants provider	Insufficient ERDF funds for MAB energy renovation	Launching new regional financing instruments based on private sources or a mix (ERDF + private) for MABs energy renovation
Homeowner associations in MABs	Facilitator / beneficiary	Low cohesion of members (apartment owners) / low self-financing capacity of energy renovation works / equipment on MABs	Changes in national regulations / legislation, establishment of dedicated financing support mechanisms for MABs energy renovation
The Ministry of Development	Facilitator/grants provider	Insufficient funds available for MABs renovation	Increase the level of funding dedicated to MABs energy renovation, identify / implement hybrid financing schemes (including ESCO, PPP, etc.)
Ministry of EU Funds	Facilitator	Insufficient EU grants dedicated to MABs renovation	Identify ways to use available grants more efficiently (including combining EU grants with private financing) to support more MABs energy renovations
Alba Local Energy Agency	Facilitator	Lack of data on MABs constructive status and living conditions at local/regional level, difficult access to EU projects supporting MABs renovation	Implementing more projects dedicated to research/capacity building on MABs energy renovation, supporting municipalities in MABs data collection process, publish new methodologies technologies, best practices on MABs renovation
Apartment owners / residents	Final beneficiaries	Lack of knowledge and active involvement on: MABs energy renovation projects	MABs facilitators to increase the local meetings / home visits / workshops frequency and participation of apartment

		elaboration / implementation / financing options / available technologies	owners on the topic of MABs energy renovation
--	--	--	--

Energy renovation of MABs in Romania relies almost entirely on public grant funding, as commercial financial instruments like low-interest green loans or ESCO energy service contracts remain virtually non-existent for residential MABs. The primary national funding mechanism is PNRR Component 5 ("Renovation Wave"), which manages a 23.8 billion EUR budget and provides grants between 100,000 EUR and 5 million EUR per project, covering up to 100% of eligible costs. Regionally, the Regional Program Center (PRC) 2021-2027 managed by ADR Centru allocates 1.38 billion EUR, with Action 3.1 specifically targeting residential energy efficiency. At the local level, a crucial best practice established by the Municipality of Alba Iulia is the full absorption of the mandatory 2% local co-financing rate required under regional schemes, along with all non-eligible technical expenses. By lifting this direct financial burden from homeowners associations and low-income residents, the municipality eliminates the primary economic barrier to deep renovation. In 2025, the local administration submitted funding applications for several unrenovated MABs in pilot areas, absorbing total renovation costs that often exceed 1 million EUR per building.

Formulating the local investment plan requires transitioning from ad-hoc building selection to a transparent, data-driven methodology. Under the CEESEN-BENDER project, a digital building prioritization tool was created in R Studio, ranking 30 candidate MABs in Alba Iulia based on a multi-criteria matrix integrating construction age, vacant housing rates, unemployment, social assistance reliance, proportion of minors, average income, and space heating costs. Furthermore, technical intervention packages have been standardized with estimated unit costs per square meter of usable apartment area, including building envelope insulation and roof refurbishment (~210 EUR/m²), staircase-integrated mechanical ventilation with heat recovery and air quality sensors (~100 EUR/m²), photovoltaic solar systems (~40 EUR/m²), facade shading systems (~100 EUR/m²), exterior elevators and emergency evacuation stairs (~60 EUR/m²), urban heat island mitigation measures (~100 EUR/m²), window and balcony awnings (~10 EUR/m²), and attached structural balcony extensions (~100 EUR/m²). Financial simulations using the project's simplified ROI Calculator reveal that deep renovation yields a long-term amortization period of around 23 to 33 years across pilot buildings, underscoring the absolute necessity of public grant support.

Energy performance synthesis

The energy performance indicators for the Romanian pilots in Alba Iulia target six unrenovated communist-era multi-apartment buildings (MABs) constructed primarily between 1960 and 1980. Characterised by precast reinforced concrete panels, structural brick masonry, and obsolete space heating systems, these legacy blocks exhibit severe systemic energy deficiencies, falling into baseline Energy Performance

Certificate (EPC) classes C or D with space heating demands ranging between 171.74 and 292.17 kWh/m² per year. Collectively, the six targeted buildings represent an annual baseline final energy consumption of 6.541 GWh/year. The proposed deep renovation roadmaps aim to achieve a substantial average heating demand reduction of 40.44% across the portfolio. This comprehensive thermal upgrade is projected to deliver 2.697 GWh/year in final energy savings and 3.506 GWh/year in primary energy savings, translating into an average EPC improvement of 1.3 class steps and direct greenhouse gas mitigations of 555 tCO₂/year. Furthermore, the roadmaps map out a substantial solar renewable energy potential of 0.900 GWh/year to be generated via standardized rooftop and balcony solar photovoltaic installations to support local energy self-consumption

For all MABs included in your roadmap	Unit	Romania
Number of MABs included in the roadmap (to be renovated)	-	6
Baseline final energy consumption before renovation	GWh/yr	6,541
Final energy savings after renovation	GWh/yr	2,697
Primary energy savings after renovation	GWh/yr	3,506
Estimated CO ₂ reduction after renovation	tCO ₂ /yr	555
Energy Performance Certificate class improvement (average)	class diff.	1.3
Renewable energy potential	GWh/yr	0.900
Expected reduction of heating demand (average)	%	40,440

The roadmap details comprehensive technical, energetic, indoor air quality, and financial evaluations for six representative pilot MABs in Alba Iulia. Pilot Building BL. G5-G6, located at Str. Alexandru Ioan Cuza Nr. 16, was built in 1975 and comprises 40 apartments with a total heated area of 2,272 m². Moving from energy class C (253.08 kWh/m²/yr) to model class B (152.72 kWh/m²/yr) achieves estimated annual gas energy savings of 228 MWh (€13,283/yr) and CO₂ emission reductions of 49 tonnes/yr, alongside an estimated rooftop and balcony PV output of 89 MWh/yr (€8,641/yr). With a total primary renovation CapEx of €795,200 (€19,880/apartment) and an overall ROI of 31 years, the renovation increases property market value by +€300/m² (€17,040 net equity gain per apartment). Pilot Building BL. 2 CDEF, located at Str. Cloșca Nr. 10, was built in 1983 and contains 38 large apartments with a heated area of 3,875 m². Transitioning from class D (309.23 kWh/m²/yr) to class B (200.93 kWh/m²/yr) yields energy savings of

420 MWh/yr (€24,446/yr) and CO₂ reductions of 86 tonnes/yr, complemented by a PV potential of 156 MWh/yr (€15,146/yr). Total primary renovation CapEx is €1,356,250 (€35,691/apartment) with an overall ROI of 29 years, boosting apartment market value by +€300/m² (€30,592 net gain per unit).

Pilot Building BL. 26-27, situated on Bulevardul Transilvaniei, was constructed in 1971 and houses 59 apartments across a heated area of 4,080 m², with approximately 30% of residents facing energy poverty. Upgrading from energy class C (287.99 kWh/m²/yr) to class B (147.41 kWh/m²/yr) delivers annual energy savings of 574 MWh (€33,412/yr) and CO₂ reductions of 118 tonnes/yr, alongside a total PV generation potential of 170 MWh/yr (€16,505/yr). Total primary renovation CapEx stands at €1,428,000 (€24,203/apartment) with an overall ROI of 25 years, enhancing unit market values by +€300/m² (€20,746 net gain per unit). Pilot Building BL. 71-72-73, located at Bulevardul Gheorghe Șincai Nr. 27-31, is a 1986 Soviet T770 diaphragm structure containing 53 apartments and a heated area of 3,931 m², where 40% of residents are energy vulnerable. Improving performance from class C (221.79 kWh/m²/yr) to class B (148 kWh/m²/yr) results in energy savings of 290 MWh/yr (€16,897/yr) and CO₂ reductions of 59 tonnes/yr, paired with a PV potential of 182 MWh/yr (€17,670/yr). Total primary renovation CapEx is €1,375,850 (€25,959/apartment) with an overall ROI of 33 years, resulting in a market value uplift of +€300/m² (€22,251 net gain per unit).

Pilot Building BL. B1-B5, located at Str. Orizontului Nr. 8-16, was built in 1983 and represents a large 5-entry MAB containing 93 apartments across 5,073 m² of heated area. Upgrading from energy class D (371.32 kWh/m²/yr) to model class C (205.97 kWh/m²/yr) generates substantial energy savings of 839 MWh/yr (€48,863/yr) and CO₂ reductions of 172 tonnes/yr, complemented by a PV generation potential of 205 MWh/yr (€19,903/yr). Total primary renovation CapEx is €1,775,550 (€19,092/apartment) with an overall ROI of 23 years, driving a market value appreciation of +€300/m² (€16,365 net gain per unit). Pilot Building BL. 46 CĂMIN, situated at Str. Livezii Nr. 46, was constructed in 1979 as a studio hostel block containing 92 small 27 m² studios across 2,467 m² of heated area. Upgrading from energy class D (339.70 kWh/m²/yr) to class B (199.22 kWh/m²/yr) yields energy savings of 347 MWh/yr (€20,188/yr) and CO₂ reductions of 71 tonnes/yr, alongside a PV potential of 98 MWh/yr (€9,515/yr). Total primary renovation CapEx is €863,450 (€9,385/studio) with an overall ROI of 25 years, boosting unit market value by +€300/m² (€8,045 net gain per studio). Additionally, BL. 46 CĂMIN offers a specialized option for apartment recompartmentation, where two or more small 27 m² studios can be merged into 50–80 m² family apartments through municipal or developer buyouts to drastically improve living quality.

Practical implementation of renovation works in Alba Iulia requires a structured sequence of next steps grounded in empirical field data. The local administration must update energy audits, prepare detailed engineering documentation (DALI and Feasibility Studies), and utilize the R Studio prioritization tool to establish transparent investment queues across all remaining unrenovated MABs. Technically, future projects must mandate the inclusion of staircase-integrated MVHR systems to ensure healthy

indoor air and prevent mold, while installing rooftop and balcony PV systems to support energy self-consumption. Local authorities and ALEA will facilitate the creation of Renewable Energy Communities among homeowners associations to enable collective prosumer energy sharing. Crucially, social engagement and direct citizen support must be maintained through home visits, thermal camera inspections, energy bill counseling, advocacy workshops, and demonstration building visits to build community trust, lower social resistance, and secure mandatory legal voting majorities within HOAs.

The roadmaps highlight critical policy improvements needed at national, regional, and local levels. Nationally, Romania must establish a clear legal definition and standardized indicators for energy poverty, replacing "first-come, first-served" grant allocations with mandatory socio-economic vulnerability criteria. National frameworks should also enforce regional fund distribution equity, strengthen legal provisions for building-level Energy Communities, and develop alternative commercial financial tools like ESCO energy performance contracts and state-guaranteed loans. Regionally and locally, authorities should maintain a centralized digital MAB inventory tracking structural degradations and resident demographics, streamline communication between ADR Centru and HOAs, and operationalize a permanent integrated Energy Poverty Advisory Center (One-Stop-Shop) in Alba Iulia.

The building-level roadmaps create direct synergies and add substantial strategic value to Alba Iulia's broader planning tools. They directly operationalize the targets of Alba Iulia's Sustainable Energy and Climate Action Plan (SECAP/PAEDC), which aims to rehabilitate 2,147 apartments across 30 MABs, and reinforce the Integrated Urban Development Strategy (SIDU) by transforming general emission reduction goals into detailed, bankable building-level investment plans. Furthermore, the roadmaps align with other EU-funded initiatives in Alba Iulia, including DOITSMARTER (Innovation Norway social assistance mapping), the Energy Poverty Advisory Hub (EPAH), CEESEU-DIGIT, MESTRI-CE, and the Building Efficiency Accelerator (BEA). The CEESEN-BENDER project delivers tangible added value through open-source tools—such as the simplified ROI Calculator, R Studio Prioritization Tool, and MAB PV Output Calculator—combined with 12-month indoor air quality datasets and field counselling protocols, establishing a highly replicable model for equitable urban energy transition across Central and Eastern Europe.



The CEESEN-BENDER project has received funding from the European Union's Programme for the Environment and Climate Action (LIFE 2021-2027) under grant agreement no LIFE 101120994. The information and views set out in this material are those of the author(s) and do not necessarily reflect the official opinion of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.



CEESEN-BENDER

**Building intErventions in vulNerable Districts against
Energy poveRty**

Deliverable 5.3

**Report on building – level renovation roadmaps in 5
pilot regions**

**Renovation roadmaps and investment strategies for
buildings in the pilot region Wawrzyszew Pilot Area,
Warsaw (Poland)**

- Summary -

Dissemination Level: Public

WP5 Creating roadmaps and support services for building energy renovations for vulnerable districts

Warsaw, 2026



**Co-funded by
the European Union**



**CENTRAL & EASTERN EUROPEAN
SUSTAINABLE ENERGY NETWORK
CEESEN-BENDER**

Building – level renovation roadmaps and investment strategies for pilot multiapartment buildings in Wawrzyszew Pilot Area, Warsaw (Poland)

The six pilot buildings assessed within the CEESEN-BENDER project represent typical multi-family residential buildings located in both Warsaw and the rest of the country. Although they differ in size, construction period and previous renovation history, they share similar technical and operational challenges typical of post-war residential buildings.

The building assessments combined:

- Technical analyses,
- Indoor environmental quality (IEQ) monitoring,
- Resident consultations,
- Advisory visits,
- And, where available, Energy performance assessments.

The monitoring campaign (May 2024 – May 2025) evaluated indoor temperature, relative humidity and CO₂ concentration in apartments and common areas, providing valuable information on both building performance and occupants' comfort.

Main findings

1. Summer overheating

All monitored buildings experienced overheating during summer.

Apartment temperatures frequently reached 25–29°C, while temperatures in common areas often exceeded even 30°C. Although winter thermal conditions were generally acceptable, summer overheating significantly reduced occupants' comfort and is expected to become an increasing problem due to climate change.

2. Indoor air quality requires improvement

The most consistent issue identified across all pilot buildings was insufficient ventilation inside apartments.

Measured CO₂ concentrations regularly exceeded recommended indoor air quality limits:

- Sokratesa 2B – up to 1,900 ppm
- Wolumen 6 – over 3,000 ppm
- Wolumen 4 – nearly 3,000 ppm
- Szekspira 4 – approximately 1,600–1,700 ppm
- Reymonta 23 – approximately 1,500–1,800 ppm
- Petöfiego 1 – approximately 2,000 ppm

In contrast, CO₂ levels in common areas generally remained within acceptable ranges, indicating that ventilation deficiencies mainly occur inside occupied apartments rather than in shared spaces.

3. Indoor humidity remains generally acceptable but decreases during winter

Relative humidity inside apartments was usually within a comfortable range.

However, common areas frequently experienced very low humidity during the heating season, occasionally dropping below 20%, which may reduce occupants' comfort and negatively affect indoor environmental quality.

4. Previous thermal retrofits improved Energy performance but further optimisation is needed

Several buildings had already undergone comprehensive thermal renovation, including:

- Roof insulation,
- Facade insulation,
- Building envelope improvements.

These measures significantly reduced heat losses.

Nevertheless, the analyses showed that additional improvements are still possible, particularly through:

- Ventilation improvements,
- Renewable energy integration,
- Better energy management,
- Optimisation of technical systems.

Buildings that had already been renovated now require optimisation rather than another full-scale thermal retrofit.

Building observations

1. Sokratesa 2B

The building demonstrates good overall technical condition but suffers from:

- Elevated CO₂ concentrations,
- Roof leakage and local moisture problems reported by residents,
- Overheating during summer.

A photovoltaic installation (16.84 kWp) has been technically designed and represents one of the most economically attractive investments identified within the project.

2. Wolumen 6

The largest challenges include:

- The highest recorded CO₂ concentrations,

- Poor air circulation,
- Mould and excessive indoor humidity reported during advisory visits,
- Overheating during summer.

A 24.57 kWp photovoltaic system has been designed for the building and is expected to substantially reduce electricity costs for common areas.

3. Wolumen 4

The monitoring confirmed:

- Recurring overheating,
- Insufficient ventilation,
- Extremely high CO₂ concentrations,
- Very low humidity in common areas during winter.

A 12.74 kWp rooftop photovoltaic installation has been proposed as the first stage of further energy improvements.

4. Szekspira 4

This building has already undergone major thermal modernisation.

The remaining priorities concern:

- Maintaining the achieved energy performance,
- Improving ventilation,
- Reducing overheating,
- Expanding the existing photovoltaic installation,
- Improving operation and maintenance of technical systems.

5. Reymonta 23

Previous renovation significantly improved energy performance.

Further improvements should focus on:

- Optimisation of technical installations,
- Ventilation efficiency,
- Mitigation of overheating,
- Expansion of renewable energy systems,
- Implementation of smart energy management solutions.

6. Petofiego 1

The building is also thermally renovated and performs relatively well.

Remaining issues include:

- Elevated CO₂ concentrations,
- Overheating in common areas,
- Low winter humidity,
- Opportunities for further optimisation of ventilation and technical systems.

The building no longer requires major structural renovation but rather operational improvements and continuous optimisation.

Common recommendations and overall conclusions

Based on the analyses performed across all six pilot buildings, the following actions are recommended.

- Improve ventilation;
- Reduce overheating;
- Continue improving energy efficiency;
- Expand renewable energy use;
- Apply a staged renovation approach.

The six pilot buildings demonstrate that improving indoor environmental quality should receive the same attention as energy efficiency during renovation planning. While previous thermal retrofits have successfully reduced heat losses in several buildings, monitoring revealed persistent issues related to ventilation, overheating and indoor comfort. Future renovation programmes should therefore combine energy efficiency measures with climate adaptation, indoor air quality improvements and renewable energy deployment. An integrated, staged renovation strategy will maximise environmental, economic and social benefits while improving residents' quality of life across the Wawrzyszew pilot area.



Co-funded by
the European Union

The CEESEN-BENDER project has received funding from the European Union's Programme for the Environment and Climate Action (LIFE 2021-2027) under grant agreement no LIFE 101120994. The information and views set out in this material are those of the author(s) and do not necessarily reflect the official opinion of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.