CEESEN-BENDER

Building intErventions in vulNerable Districts against Energy poveRty

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WP3 Tackling the barriers hindering building related interventions in vulnerable districts

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Comparative Analysis of Energy Renovations of Multi-apartment Buildings and Energy Poverty across CEESEN-BENDER Pilot Areas

Summary

Based on a cross-sectional survey conducted in 2024 across five pilot sites in Central and Eastern Europe—Čakovec (HR), Tartu (EE), Warsaw (PL), Alba Iulia (RO) and Ptuj (SI)—as part of the CEESEN-BENDER project (*Building intErventions in vulNerable Districts against Energy poveRty*), this article presents descriptive comparisons of attitudes of residents of multi-apartment buildings by site and renovation status. The data shows that homeowners and tenants of renovated buildings generally report fewer housing condition defects, higher perceived energy efficiency, and better winter/summer comfort, yet affordability pressures persist and are not uniform. Payment arrears regarding utility bills are much lower in renovated stock in Warsaw (3.0% vs 15.5%) but are similar or slightly higher in the renovated stock in Alba Iulia and Čakovec. Renovated buildings tend to combine higher thermal comfort with lower reports of "can't afford warmth", though summer cooling remains a challenge in Ptuj and Tartu. Most sites show a shift from envelope defects (façade/roof/windows) in unrenovated buildings to common-area and service issues (elevators, waste, drainage) in renovated buildings, while some issues in buildings, like ventilation in Tartu, persist. Across sites, respondents more often feel informed about building-level decisions than involved in them, indicating a participation gap. As this analysis is descriptive and cross-sectional, it describes the sample and does not establish causal effects. A deeper look into the survey data is needed to establish statistically backed differences between groups and to better inform research on renovation impacts on policy issues such as energy poverty and overall quality of life in multi-apartment buildings.

Introduction

The main goal of the project "Building intErventions in vulNerable Districts against Energy poveRty" (CEESEN-BENDER), launched on 1 September 2023, is to empower and support vulnerable homeowners and tenants living in buildings built after the Second World War and before 1990's in 5 CEE countries: Croatia, Slovenia, Estonia, Poland, and Romania. One of the project's more specific goals is to empower and support vulnerable homeowners and tenants residing in multi-apartment buildings (MABs) throughout the renovation process by identifying key obstacles and providing reliable support services that encompass homeowners, their associations, and building managers. To address some of the identified obstacles to energy efficiency in MABs and aspects of energy poverty[1], data on households' energy characteristics, energy-consumption habits and attitudes, the renovation process, energy poverty, and quality of life were collected in five pilot sites via face-to-face quantitative surveys.

Although energy poverty is not a new policy topic, data on energy poverty are scarce and are usually collected under specific circumstances, such as targeted calls, programmes, or projects. In most cases, conclusions and partial data on energy poverty are drawn from the EU Survey on Income and Living Conditions (EU-SILC) or the Household Budget Survey (HBS). Moreover, while both surveys collect data in a harmonised manner in all member states, they do not specifically collect all the relevant or needed data for the specific national or local analysis of energy poverty.

[1] In 2023, the amended Energy Efficiency Directive was adopted at the EU level. Article 2 of the Directive (EU) 2023/1791 defines energy poverty as follows: " 'energy poverty' means a household's lack of access to essential energy services, where such services provide basic levels and decent standards of living and health, including adequate heating, hot water, cooling, lighting, and energy to power appliances, in the relevant national context, existing national social policy and other relevant national policies, caused by a combination of factors, including at least non-affordability, insufficient disposable income, high energy expenditure and poor energy efficiency of homes;".

Figure 1. CEESEN-BENDER partners visiting a renovated building in the pilot-site Tartu (Estonia) in September 2024.

In the case of the CEESEN-BENDER project, the purpose of the survey was to collect data on energy poverty in the context of energy renovation of MABs constructed between 1945 and 1991, as well as on the quality of life of households in renovated and unrenovated buildings. We also sought to investigate the reasons for deciding to renovate a building. This article presents selected descriptive findings of key topics relevant to the subjective aspects of energy poverty, the conditions under which households live pointing to energy (in)efficiency of their homes, along with "effects" of energy renovations of MABs, primarily through comparing results on energy-related aspects such as heating sources used, thermal comfort indicators, and financial ability to afford adequate levels of thermal comfort, etc. By such descriptive comparisons we describe some determinants of shared experiences across pilot sites, as well as pinpoint areas of further inquiry regarding real-life effects of energy renovations on households' quality of life and energy poverty in CEE regions.

About the research

To help investigate these topics in more detail, a survey was designed and conducted with a total of 2,034 participants across the five pilot sites. The main goal was to collect information on the implementation of energy renovation in multi-apartment buildings in the CEE countries included in the project, and to compare these findings with the data collected in unrenovated buildings. Finally, with we aimed to establish the experiential and perceptual determinants that contribute to or hinder the implementation of energy renovation in multi-apartment buildings, and to identify social and economic barriers to renovation from the perspective of co-owners (tenants) of multi-apartment buildings. Our questionnaire collected mostly quantitative data on energy consumption and savings in households, and on tenants' satisfaction with the quality and different aspects of everyday residential life in (un)renovated buildings. Data collection periods in each pilot sites varied, lasting from approximately two weeks up to one month, with the entire data collection process taking place from mid-April until late November 2024.

The data were collected mainly via face-to-face surveying conducted within buildings across all pilot areas, coordinated and carried out by subcontracted regional research agencies. The questionnaire, which on average took between 30 and 40 minutes to complete, consisted of 219 variables grouped into instruments and items in four sections: (A) housing, energy renovation and energy poverty; (B) quality of housing; (C) health; and (D) socio-demographic data, with 14, 17, 5 and 13 questions respectively. Section A covered housing status, building characteristics, renovation involvement, energy efficiency and sources, energy habits/consumption and thermal comfort. Section B asked about satisfaction with building characteristics, problems/defects, reserve funds and investments, and interpersonal relations/meetings. Section C gathered general health data (physical and psychological). Section D recorded socio-demographic information.

The sample in each pilot site consisted of at least 400 respondents, with a minimum of 200 situated in renovated buildings and 200 situated in unrenovated buildings. Participation in the survey was anonymous and voluntary for adult members of the household over the age of 18. Only one participant per household was interviewed, and this person needed to have some basic knowledge of energy renovation and the energy consumption of the household. Sampling followed a two-stage design: project partners purposively selected eligible multi-apartment buildings (constructed 1945–1991) and compiled precise addresses within each pilot site. Within each selected building, field agencies used standard within-building probability procedures to randomly select households and one eligible adult respondent per household (e.g., pre-assigned random household lists and respondent-selection grids), ensuring balanced counts by renovation status.

Overall, the survey included 60% female and 38% male participants, with the remaining 2% other. The City of Alba Iulia (RO) has the highest percentage of female participants (67%), while the City of Warsaw (PL) has the lowest (53%). Based on the age distribution across all pilot sites, the 18–34 age group represented 18% of participants (lowest), and the 65+ group represented 35% (highest). In the City of Ptuj (SI), the share aged 18–34 was as low as 6%, whereas the 65+ group reached 54%. Warsaw (PL) has the highest share aged 18–34 (27%) and the lowest 65+ share (17%). By employment status overall, 53% of participants were employed, 2% unemployed, and 36% retired. The highest percentage of retired participants was in Ptuj (58%) and the lowest in Warsaw (17%). Remaining 9% refer to students, homemakers, disabled and other statuses. Tenure status across all sites was 75% owner-occupiers, including mortgage holders, 18% tenants, and 7% residents not paying rent (e.g. family owned or social housing with zero rent). The highest share not paying rent was in Alba-Iulia (10%) and the lowest in the City of Čakovec (HR) (4%).

Energy renovation of buildings and energy poverty in the CEESEN-BENDER pilot areas

The results reported here are descriptive only[2], portraying data without evaluating hypotheses. This initial step clarifies distributions and relationships and will guide the specification of subsequent models and the selection of appropriate tests. No survey weights were constructed; analyses report unweighted estimates with corresponding bases, where applicable (n/N). The presented groups (renovated vs. unrenovated) are independent (cross-sectional), not longitudinal baselines.

One of the questions that indicates a higher risk of energy poverty is the presence of housing-condition problems: mould, draught (air leakage), and rot in window or door frames. When asked about these problems, residents of both renovated and unrenovated buildings reported issues in their homes. The share reporting any problem is lower among residents of renovated buildings (3.9%) than among residents of unrenovated buildings (9.8%). After renovation, such problems would typically be expected to be absent or at least reduced. Residents mainly report mould, with the highest percentages in Ptuj (28.5% in unrenovated and 16.5% in renovated buildings) and Alba Iulia (21.5% and 9%, respectively).

[2] Percentages may not sum to 100% due to rounding: "Don't know"/NA excluded unless stated.

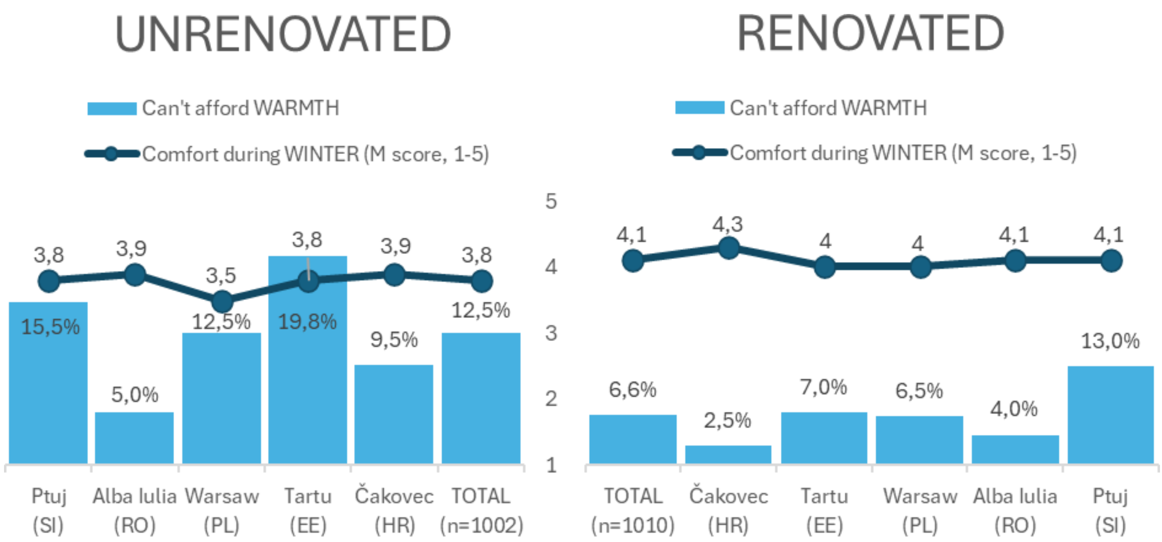
Across the five pilot sites, comparisons between the two groups show systematically lower prevalences for several specific defects in the renovated stock: draught through windows (17.4% unrenovated vs 6.7% renovated), mould (18.1% vs 8.5%), damp walls (14.9% vs 6.9%), and draught through doors (14.9% vs 6.9%). However, pilot site patterns diverge. In Tartu (EE), for example, leaking roofs are reported by 10.9% of households in unrenovated buildings versus 0.9% in renovated, and window draught by 26.7% versus 6.6%. In Ptuj, the renovated stock still shows comparatively high levels on several items (mould 16.5%, damp walls 12%, leaking roof 9%). Čakovec (HR) shows comparatively lower shares in the renovated group for mould (8.0%) and draught, Alba Iulia (RO) reports mould at 9.0% in the renovated group, and Warsaw (PL) begins from low levels overall but reports residual draught (door 9%, windows 7%) alongside a small difference in leaking roofs (2.0% unrenovated vs 3.0% renovated).

Figure 2. CEESEN-BENDER partners visiting a renovated building in Szczytno (Poland) in May 2025

Another important question for determining the risk of energy poverty is households' ability to pay utility bills, specifically the presence of arrears in the last 12 months. The largest difference appears in Warsaw (PL), where 15.5 % of respondents in unrenovated buildings (31 of 200; 95 % CI 10.5 %–20.5 %) reported arrears compared with 3.0 % in renovated buildings (6 of 200; 95 % CI 0.6 %–5.4 %); this yields a prevalence ratio of 0.19 (95 % CI 0.08–0.45) and an absolute difference of –12.5 percentage points (SE 2.83 pp). In Tartu (EE), 9.4 % of households in unrenovated stock (19 of 202; 95 % CI 5.4 %–13.4 %) had arrears compared with 5.6 % in renovated buildings (12 of 213; 95 % CI 2.5 %–8.7 %); the prevalence ratio is 0.60 (95 % CI 0.30–1.20) and the difference −3.77 point (95 % CI –8.85–1.31). Čakovec (HR) shows very little difference: 3.0 % of respondents in unrenovated buildings (6 of 200; 95 % CI 0.6 %–5.4 %) reported arrears compared with 3.5 % in renovated buildings (7 of 200; 95 % CI 1.0 %–6.0 %), giving a prevalence ratio of 1.17 (95 % CI 0.40–3.41) and an absolute difference of +0.5 percentage points (95 % CI –2.98–3.98). Alba Iulia (RO) further reinforces this somewhat surprising trend with 7.6 % of unrenovated households (15 of 197; 95 % CI 3.9 %–11.3 %) reported arrears versus 9.9 % in renovated buildings (19 of 192; 95 % CI 5.7 %–14.1 %), providing a prevalence ratio of 1.30 (95 % CI 0.68–2.48) and an absolute difference of +2.28 points (95 % CI –3.34–7.90). In Ptuj (SI), the prevalence is identical at 9.0 % in both groups (18 of 200 in each; 95 % CI 5.0 %–13.0 %), so the prevalence ratio is 1.00 (95 % CI 0.54–1.87). At the aggregate level, totals are 8.9 % in unrenovated buildings (n = 999) and 7.5 % in renovated buildings (n = 1,005), underscoring that technical renovations alone may not fully address the drivers of payment difficulties.

Residents of renovated buildings across the pilot sites report higher winter comfort than those in unrenovated stock (mean[3] 4.1 vs 3.8). In renovated buildings, roughly 90% describe their winter comfort as pleasant or extremely pleasant (pleasant 66.3%, extremely pleasant 23.7%) compared with about 72% in unrenovated buildings (pleasant 57.9%, extremely pleasant 13.8%). The share reporting they cannot afford adequate warmth is lower in the renovated group overall (6.6% vs 12.5%), with site patterns of interest: Čakovec (HR) 2.5% vs 9.5%; Tartu (EE) 7.0% vs 19.8%; Warsaw (PL) 6.5% vs 12.5%; Alba Iulia (RO) 4.0% vs 5.0%; and Ptuj (SI) 13.0% vs 15.5%. Renovated buildings therefore tend to combine higher reported comfort and lower affordability constraints, although Ptuj retains the largest residual difficulty with winter warmth among renovated sites. Figure 3 juxtaposes reported comfort with affordability constraints.

Figure 3. Winter comfort vs "can't afford to keep home pleasantly warm during winter", by renovation site and status.



Summer comfort favours the renovated stock (mean 3.8 vs 3.6), with 74% of respondents in renovated buildings rating conditions as pleasant or extremely pleasant (56.3% + 17.5%) compared with 62% in unrenovated (50.4% + 11.1%). Cooling affordability constraints are more common than winter warmth and vary widely by site: totals are 20.4% in renovated vs 26.9% in unrenovated. Shares are highest in Tartu and Ptuj (renovated 48.4% and 24.5%; unrenovated 55.0% and 32.5%) and lowest in Čakovec (renovated 6.0%, unrenovated 9.5%). Notably, Poland departs from the overall pattern (renovated 15.5% vs unrenovated 0.5%), indicating that improved comfort does not always coincide with lower reported barriers to cooling. Taken together, the data suggest that renovation is consistently associated with better thermal comfort and some reduction in reported affordability barriers, with summer cooling emerging as the more persistent challenge in several sites.

When asked to assess satisfaction[4] with construction quality, maintenance, energy efficiency, and the exterior of the building, residents in renovated buildings are generally more satisfied across all categories. In unrenovated buildings, (very) dissatisfied responses on energy efficiency vary by pilot site—50.0% in Čakovec (HR), 49.0% in Tartu (EE), 34.5% in Ptuj (SI), 11.1% in Alba Iulia (RO), and 7.5% in Warsaw (PL)—which may reflect differences in how "energy efficiency" is understood locally. For energy efficiency, the (very) satisfied share is higher in renovated than unrenovated buildings in every pilot site (Čakovec 92.5% vs 16.0%; Tartu 70.9% vs 22.3%; Warsaw 85.5% vs 58.0%; Alba Iulia

[3] Unweighted arithmetic average of respondents' 1–5 Likert ratings (1 = "Extremely unpleasant"; 5 = "Extremely pleasant") to the question(s) "How would you describe the feeling of comfort in your living space in winter/summer?"
[4] Based on a 1–5 Likert scale aggregated to bottom-2/neutral/top-2.

89.4% vs 69.7%; Ptuj 67.0% vs 38.0%). Overall satisfaction shows the same pattern (Čakovec 94.5% vs 22.5%; Tartu 76.0% vs 29.7%; Warsaw 86.5% vs 8.5%; Alba Iulia 84.5% vs 59.0%; Ptuj 67.0% vs 46.5%). Post-renovation satisfaction levels are comparatively lowest in Ptuj (e.g., construction quality 55.0%; maintenance 64.5%; energy efficiency 67.0%; exterior 72.0%; overall 67.0%), while Warsaw's unrenovated group already reports relatively high satisfaction on construction and maintenance (63.0% and 62.0%).

Table 1. Energy poverty indicators by pilot site and renovation status.

Pilot site	Arrears on utility bills % (Unren)	Arrears on utility bills % (Ren)	Can't afford warmth % (Unren)	Can't afford warmth % (Ren)	Can't afford cooling % (Unren)	Can't afford cooling % (Ren)
Čakovec (HR)	3.0	3.5	9.5	2.5	9.5	6
Tartu (EE)	9.4	5.6	19.8	7.0	55	48.4
Warsaw (PL)	15.5	3.0	12.5	6.5	0.5	15.5
Alba Iulia (RO)	7.6	9.9	5.0	4.0	21.5	20.5
Ptuj (SI)	9.0	9.0	15.5	13.0	32.5	24.5

Notes: Unren = unrenovated; Ren = renovated. Unweighted descriptive percentages, as reported in the Results. Bases (n/N) are provided in-text where applicable.

Across pilot sites, reducing costs (heating bills, hot water, etc.) is the dominant motivator[5] (Čakovec (HR) 92, Tartu (EE) 106, Warsaw (PL) 9, Alba Iulia (RO) 59, and Ptuj (SI) 149), followed by improving the overall quality of life (HR 60, EE 90, PL 7, RO 38, SI 77) and improving the building's energy performance (HR 43, EE 78, PL 10, RO 50, SI 120). Two site-specific patterns stand out. In Čakovec, respondents more often elevate greater winter comfort (HR 47) relative to "improving energy performance" (which still ranks relatively high), whereas in Alba Iulia aesthetics (RO 47) is selected more often than "overall quality of life" (still comparatively high). Comfort-oriented motives sit mid-tier overall. Greater heat in winter (HR 47, EE 44, PL 4, RO 28, SI 62) consistently outranks better summer cooling (HR 38, EE 9, PL 2, RO 13, SI 23) and reducing greenhouse-gas emissions remains a low-frequency driver across sites (HR 4, EE 2, PL 1, RO 5, SI 8).

Unrenovated buildings across all pilot sites cluster around envelope/efficiency-related issues: façade, roof, and windows/doors: this pattern is clear in Čakovec (HR) (façade 110, windows & doors 67, roof 49), Tartu (EE) (façade 86, ventilation 60, staircases/public space 48), Warsaw (PL) (elevator 73, windows & doors 34, ventilation 32), Alba Iulia (RO) (roof 24, façade 51, elevator 34), and Ptuj (SI) (façade 56, roof 34, staircases/public space 30). In the renovated stock the problem mix shifts toward common-area systems and services: elevators and waste/collection or drainage systems feature prominently—PL (elevator 53, windows & doors 17, ventilation 17), RO (staircases/public space 24, elevator 46, waste collection 23), SI (elevator 25, waste collection 23, plumbing 21), and HR (stormwater drainage 21, entrance door 20, sewage 20); EE remains ventilation-focused (ventilation 53, staircases/public space 34, façade 24). "No significant problems" is more frequently selected in renovated than unrenovated buildings in every pilot site (HR: 93 vs 22; EE: 77 vs 22; PL: 122 vs 87; RO: 106 vs 96; SI: 72 vs 54) with the largest gaps in Čakovec and Tartu, suggesting stronger perceived gains there. Consistent with the broader pattern, unrenovated issues largely reflect energy-efficiency and envelope defects (façade/roof/windows), while post-renovation concerns tilt toward elevator reliability, waste handling, and drainage/sewage, pointing to maintenance and common-area

[5] Respondents could select up to three factors.

management as the next bottlenecks. Notably, Tartu and Warsaw show the same three categories topping both statuses (albeit in different orders), hinting at systemic issues that persist regardless of renovation status.

Table 2. Energy-efficiency related overview by pilot site and renovation status.

Pilot site	"(Very) satisfied" with EE % (Unren)	"(Very) satisfied" with EE % (Ren)	Dominant problem cluster (Unren)	Dominant problem cluster (Ren)	"No significant problems" (Unren, count)	"No significant problems" (Ren, count)
Čakovec (HR)	16.0	92.5	Façade/windows& doors / roof	Drainage / entrance door / sewage	22	93
Tartu (EE)	22.3	70.9	Façade / ventilation / staircases	Ventilation / staircases / façade	22	77
Warsaw (PL)	58.0	85.5	Elevator / windows & doors / ventilation	Elevator / windows & doors / ventilation	87	122
Alba Iulia (RO)	69.7	89.4	Roof / façade / elevator	Staircases & public space / elevator / waste	96	106
Ptuj (SI)	38.0	67.0	Façade / roof / staircases	Elevator / waste / plumbing	54	72

Notes: EE = energy efficiency. Problem clusters reflect the top reported categories (short labels). Counts for "No significant problems" are frequencies reported in the Results (not percentages). Unweighted descriptive summaries.

Furthermore, respondents in the renovated group report stronger acceptance of joint ownership than those in the unrenovated group: "fully accepting" rises from 15.3% to 19.6%, while "not accepting" falls from 15.3% to 8.0% (partial acceptance: 69.4%→72.5%). The sharpest contrast appears in Čakovec (HR): not accepting 24.5%→8.0%, fully accepting 13.5%→31.0%, suggesting greater alignment around common-area stewardship in the renovated stock. Tartu (EE) also shows higher full acceptance (14.9%→22.5%) and low outright rejection (7.9%→5.2%). Ptuj (SI) shifts towards fuller acceptance (16.0%→23.5%) with a drop in non-acceptance (22.0%→14.0%). In Alba Iulia (RO), non-acceptance decreases (15.1%→7.4%) although full acceptance dips (17.1%→13.2%) as partial acceptance grows. Warsaw (PL) remains distinctive. Partial acceptance dominates (78.0%→87.5%), while full acceptance is comparatively low (9.0%→7.0%). Overall, in both groups a large majority at least partially accept the notion of joint ownership (unrenovated 84.7%, renovated 92.1%), indicating considerable scope to build governance and communication around shared spaces.

Across pilot sites, information exceeds involvement: the share not informed is consistently lower than the share not involved. Renovated buildings show higher information in every site, "not (at all) informed" falls from 19.0%→13.5% in Čakovec (HR), 13.9%→4.7% in Tartu (EE), 15.7%→6.3% in Warsaw (PL), 13.6%→11.3% in Alba Iulia (RO), and 14.5%→10.5% in Ptuj (SI). Involvement improves in most places but remains the main gap: not (at all) involved is 32.5% (unrenovated) vs 30.5% (renovated) in HR, 35.2% vs 29.6% in EE, 69.4% vs 69.2% in PL, 43.7% vs 39.5% in RO, and 41.5% vs 29.0% in SI. Two contrasts stand out. Ptuj (SI) is the only site where most residents in renovated buildings report[6] being involved (53.0%), whereas Warsaw (PL) combines good information in renovated stock (6.3% not informed) with the lowest personal involvement (~69% not involved in both groups), signalling a participation bottleneck. Overall, renovated buildings tend to be better informed and somewhat more engaged, but mobilising involvement, especially in Warsaw, remains the greatest challenge.

[6] Answers „4“ and „5“ on a five-point scale for both questions (on involvement and information) where 1 = Not at all; 5= Entirely“.

Towards an integrated understanding of energy vulnerability, renovation and building-level social engagement

Energy-poverty issues emerge when comparing different buildings that are either renovated or unrenovated. The descriptive evidence here shows that, while renovated stock generally reports fewer defects (mould, draughts, damp), a non-negligible share of households in renovated buildings still face such problems. In this sense, improvements are uneven. Tartu shows large reductions in leaks and draughts, whereas Ptuj still records comparatively high levels of mould (16.5%) and damp walls (12%). Arrears on utility bills are likewise site-specific. Beyond Warsaw's large difference between unrenovated and renovated stock (15.5% vs 3.0%), a noteworthy pattern is the reversal observed in Alba Iulia and Čakovec, where the renovated stock reports arrears at similar or slightly higher shares than the unrenovated stock. This underlines that renovations alone do not uniformly coincide with better affordability outcomes. Thermal comfort (winter and summer) trends move slightly upwards in renovated buildings (mean scores ≈3.8→4.1 in winter and ≈3.6→3.8 in summer), yet a meaningful minority, especially in Ptuj for winter and Tartu for summer, still cannot afford adequate warmth or cooling even after renovation. Taken together, these cross-sectional comparisons suggest that technical upgrades are helpful but not sufficient: affordability, comfort and condition are co-produced by prices, income, behaviour, and local systems, not only by building efficiency.

Figure 4. CEESEN-BENDER partners visiting a renovated building in Szczytno (Poland) in May 2025

Perceptions of energy efficiency are consistently higher in renovated stock: (very) satisfied shares are much larger in Čakovec (92.5% vs 16.0%), Tartu (70.9% vs 22.3%) and Ptuj (67% vs 38%). In Ptuj, renovated buildings still lag the strongest performers, suggesting room for further gains. The pattern of reported problems aligns with this: unrenovated buildings tend to report envelope and efficiency issues (façade, roof, windows/doors), while renovated buildings shift toward common-area systems and services (elevators, waste handling, drainage/sewage), with Tartu remaining more ventilation-focused. Across all sites, "no significant problems" is more frequently noted in renovated stock, with the largest improvements in Čakovec and Tartu. Motivations to engage with renovation remain cost-centred (reducing energy/heating bills) but also include quality-of-life gains and improved energy performance; priorities vary by site (e.g., winter comfort in Čakovec; aesthetics in Alba Iulia).

Social capital signals are mixed. Acceptance of joint ownership is modestly higher overall in renovated buildings, with notable gains in Čakovec and Ptuj, but the information–involvement gap persists. Across sites, more residents feel informed about building decisions than feel personally involved. Renovated buildings are less likely to report being "not at all informed," yet Warsaw exemplifies a participation bottleneck (information high, involvement low), while Ptuj is the only site where a majority of residents in renovated buildings report active involvement. This perhaps points to the need for improved approach to collective action and facilitation because information alone is not sufficient to drive participative renovation efforts.

Our sampling is cross-sectional, and the present analysis is descriptive, which means the patterns reported here describe the sample and should not be generalised beyond it without caution. They do not establish causal effects between renovation status and outcomes because the groups comprise different buildings and households. Site-level sample sizes are modest, some sub-groups (e.g., households with arrears) are small, and all measures are self-reported, so recall, knowledge and social-desirability effects are possible. Also, timing, language and local framing may also shape how concepts like "energy efficiency" or "joint ownership" were understood. Even so, the dataset enables possible routes of further inquiry. For example, inferential comparisons by site and renovation status followed by adjusted models incorporating predictors such as renovation status, income proxy, tenure, age and site, plus site and renovation interactions to probe context-specific contrasts. Social-capital mechanisms can be explored via correlations or regressions linking "information" and "involvement," including simple mediation tests to see whether information predicts involvement once renovation status and site are held constant. Heterogeneity checks (by heating source, floor area, household composition) can identify groups for whom associations differ. This staged programme clarifies which contrasts are statistically reliable within the sample and where deeper, causal answers would require longitudinal follow-up or experimental/quasi-experimental designs.

Energy poverty is hard to tackle relying only on one set of measures, such as technical interventions within the building, much like it is hard to capture using only a specific type of research instruments and design. Decades of study confirm that it remains a multidimensional condition shaped by household income and debt, energy prices, dwelling efficiency and defects, health, and social inclusion. Quantitative surveys alone can only sketch parts of that picture and should always be accompanied by qualitative research to better understand the shared lived experiences and contextual factors shaped by local communities within which energy poverty emerges and/or persists. Our comparisons suggest that improving building fabric helps, but it does not guarantee affordable warmth or lower arrears when prices are high, or habits and household budgets do not shift. In fact, some sites even show higher arrears in renovated stock. This is why robust responses pair technical upgrades with targeted supports (e.g., tariff protection, staged financing, arrears management) and behaviour-oriented measures (e.g., guidance on heating/cooling practices), ideally designed and evaluated by coordinated, multidisciplinary teams. In practice, energy poverty is anchored first in the household and only then in the building. Without household-level protections and capabilities, efficiency gains could result only in better comfort but not necessarily in lower bills, which is valuable, but not a one-size-fits-all solution for managing energy poverty risk or reducing energy vulnerability.

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