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Beyond Well-Being: The Assessment of the Energy Renovation in Latvia by the Residents

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***Abstract* – Multi-family building renovation represents a key policy area at the same time, predominantly affects the daily life of residents. The paper tackles the energy renovations of multi-family buildings in Latvia. Specifically, it investigates how the renovation process affects the residents' health and well-being, their perception, and their understanding of the renovation process. To evaluate the residents' perception, a survey was conducted in thirteen buildings renovated using energy performance contracting to assess the preparation, execution, and impact of the renovation project. The survey revealed the lack of communication between the parties involved and co-design as the roadblocks to upscale the renovation process in Latvia using energy performance contracting. The paper shows aspects of the process that need to be improved to scale up the renovation in Latvia.**

***Keywords* – Energy efficiency; EPC+; ESCO; well-being.**

Nomenclature	
EU	European Union
EPC	Energy Performance Contracting
EED	Energy Efficiency Directive
EPBD	Energy Performance of Building Directive
ESCO	Energy Service Company
IEQ	Indoor Environmental Quality
OSS	One-Stop-Shop
MIS	Minimum Income Standard

1. INTRODUCTION

Buildings greatly impact our daily lives, as they influence our indoor and outdoor environment. Besides being crucial for our well-being, they are also an important policy area. Energy security and the necessity to reduce energy demand and improve energy efficiency have long been on the European Union (EU) agenda. In the time of energy crisis, when energy price rises and saving energy becomes especially important, the building sector is among the most affected and a key sector to mitigate the consequences. As an EU member, Latvia has many challenges with the quality of housing stock, most of which were constructed without energy efficiency regulations. The introduction will consider the EU and Latvia's actions on the renovation activities of the

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building stock with the reduction of energy consumption. The paper will focus on residents' well-being as an outcome of renovation to support the implementation of innovative financing schemes – Energy Performance Contracting (EPC+).

The Energy Efficiency Directive (EED) represents a core document to set energy efficiency targets for the EU in 2020 and 2030 [1]. The Directive acknowledges the crucial role of buildings as they are responsible for 40 % of the final energy consumption in the Union. The Energy Performance of Buildings Directive (EPBD) stressed the crucial need to improve the energy efficiency of buildings. The directive sets targets for renovating the total floor area for public buildings (3 %). However, there were no targets set for residential buildings [2]. Both directives are predecessors of the European Green Deal, within which the relevance of the policies increased.

The European Green Deal emerged later as a key document recognising the need for climate action and setting commitments for Member States to reduce emissions by at least 55 % by 2030 and achieve climate neutrality by 2050. Building renovation and a clean and affordable energy supply represent two key elements of the European Green Deal [3]. Renovation is an opportunity to contribute to climate neutrality. Hence, the EPBD required the Member States to prepare long-term renovation strategies. The strategies aim to make the national building stock nearly decarbonised and energy-efficient by 2050 [2].

Both Directives EED and EPBD were amended within the Clean Energy for All Europeans Package frames that introduced eight new laws and non-legislative initiatives as a part of the energy union strategy [4]. The 'Fit to 55' package was designed to revise the existing and propose new legislation and policy frameworks to meet the EU Climate Goals. The EED was revised, and energy efficiency targets increased within this package. Besides that, the emission trading system was extended to buildings. The Social Climate Fund emerged in 'Fit to 55' to assist the most affected in the EU to cover the transition costs to more energy-efficient buildings and zero or low emission mobility. It will mobilise 72.2 billion EUR within 7 years [5].

The Renovation Wave emerged as part of the Green Deal in 2020. It sets a target for 35 million buildings that should be renovated by 2030, which could create 160 000 jobs in the construction sector. Based on national long-term renovation strategies, it aimed to tackle the energy poverty that 34 million Europeans are exposed to [6]. Renewable energy use in buildings is also promoted. The target is to use 49 % of renewables by 2030 and annually increase by 1.1 % the use of renewable energy in heating and cooling. Energy Efficiency First principle is key to the Renovation Wave and long-term renovation strategies. It requires prioritising energy efficiency solutions across sectors. The principle recognises the role of buildings as a key component of the energy systems and the effective participant in demand response schemes [7].

Compared with the other Member States, the energy efficiency level in the residential sector of Latvia is in eighteenth place [8]. This situation is hardly improving as the scale of the effort does not match the scale of the problem in the public and residential sectors. The existing goals for the renovation of the buildings in the public sector were not met: 678 460 m^2 of the public buildings were planned to be renovated by 2020, whereas by 2017, only 398 707 m^2 were. This resulted in the lowering of the goal to 500 000 m^2 by 2030 [9]. This shows the need for rapid action.

The deteriorating housing stock in Latvia poses a major challenge for the energy sector. The housing sector is Latvia's second biggest final energy consumer, with 29.2 % of the total final energy use and representing up to 40 % of the country's energy portfolio [9]. The average heat energy consumption of the multifamily dwellings is 137 kWh/m^2, described as an F class in Regulation No. 222 of the Cabinet of Ministers of the Republic of Latvia [9], [10]. Out of the 39 504 multifamily dwellings from 2009 to 2019, only 838 were retrofitted, whereas the goal for

2030 is an additional 2 000 buildings [9], [11]. This would increase retrofitted dwellings to 7.18 % between 2009 and 2030.

The energy efficiency investment in the residential sector in Latvia is heterogeneous. The use of European Regional Development Funds shows that from 2009 to 2017, out of 741 retrofitting projects, only 46 were executed in the capital city of Riga. In contrast, the regions of Kurzeme and Vidzeme more proactively participated in the project development [9]. Overall in Riga, 159 buildings were renovated by the end of 2019, representing 1.4 % of the total building stock in the capital [12]. The existing trends show a need for drastic action in the sector overall with the reduction of the unequal distribution of the available funding for the residents.

The use of innovative financing schemes and support mechanisms is low in the retrofitting of multifamily buildings in Latvia. Both the National Energy and Climate Plan and the Long-term Strategy of Building Renovation identified the lack of private investment, existing obstacles in Energy Service Company (ESCO) operations, and low willingness of the residents to initiate the process as the reason for the existing crisis in the housing sector [9], [11]. The unwillingness of the residents to participate in energy retrofitting activities is particularly strong, as it is mentioned in each of the Sustainable Energy Investment Forums organised by the Executive Agency for Small and Medium-sized Enterprises in Latvia [13], [14]. Due to that, the residents should be placed in the centre of the retrofitting activities, and their concerns and needs must be met by other stakeholders involved.

Within the New European Bauhaus framework, the inclusivity of any space is considered one of the key elements in which both physical health and mental well-being prosper in both new and renovated buildings [15]. This indicates the need to evaluate the impact of existing innovative approaches to energy retrofitting projects on the different aspects of well-being, which is understudied in countries such as Latvia. The assessment of the impact of the use of innovative schemes in the facilitation of the energy retrofitting projects on the well-being of the residents will provide insight into the possible improvement strategies for such solutions with a human-centred approach. Therefore, this paper aims to determine the well-being and satisfaction with the renovation works of the residents living in the dwellings renovated by an ESCO in four cities in Latvia.

The research paper is structured as follows: in the second section, a literature review on the assessment of the impacts on the mental health of residents in the multifamily buildings, the third section will describe the methodology used for the evaluation of the impact on well-being, in the fourth section the results will be described, in the fifth section the results will be discussed, and in the sixth section the conclusions will be summarised. This research paper aims to fill the research gap in analysing the residents' self-reported well-being in connection with the building energy retrofit and their attitude towards the renovation works. The results of the research will enable a better understanding of the narrative that exists among the residents in renovated buildings as well as provide an insight into the impact the renovation works had on them.

2. Literature Review

The following section will summarise the information on the ESCOs and other business models, the link between energy poverty, health, well-being, energy efficiency and productivity, and the perception of the indoor environmental quality (IEQ) and renovation works.

2.1. ESCO Business Models

ESCOs are private-sector solutions for energy efficiency, which in developed markets facilitate the implementation of energy-saving measures. The EPCs and their modifications, such as

Integrated Energy Contracting, smartEPC, and EPC+, are used for these purposes [16]. Even though the use of the EPCs is lower in the residential sector, the outcomes in countries such as Latvia, where the EPC framework is used with the addition of national grants, are positive [16], [17]. The review of the results of energy-saving measures facilitated in 15 multifamily dwellings shows that the performance is aligned with the baseline set by the EPC and does not decrease over time [17]. Additionally, energy prices are considered one of the main factors increasing demand [16].

The IEQ and thermal comfort are the two most prominent research topics within the EPC framework and residents' well-being. The thermal comfort of the residents in the same 15 dwellings does not decrease due to the renovation [17]. In another study, the levels of thermal comfort, indoor air quality, and visual and aural comfort in renovated buildings in Finland and Lithuania by combining the measurements of the indoor pollutants and temperature with the survey data results. The results of the research concluded that most of the pollutants were within the recommended limits, but the average concentration of carbon dioxide, nitrogen dioxide, formaldehyde, benzene, toluene, ethylbenzene, and xylene due to the use of natural ventilation and higher average number of residents per apartment. Du *et al.* have also proposed using IEQ indicators as complementary parameters for the EPCs on a building level. This would lead to better living conditions for the residents in the multifamily dwellings [18].

The main drawback to developing the EPC market is the complexity of the contracts and the difficulties in evaluating the results [16], [19]. Both concerns are raised within the modifications of the standard ESCO models. *LeaseGreen* has developed an integrated solutions model based on the simplified verification and responsibility division procedures in the contract compared to the ESCO model. This resulted in the energy retrofit becoming a sustainable investment decision for the financial institutions, with co-creation being a centred value for the residents [19]. Such solutions focus on the economic prosperity of the renovation projects and incentivise the residents to pursue energy retrofitting activities due to their simplicity.

The One-Stop-Shop (OSS) business model is adopted and tested in multiple EU markets to increase cooperation between the stakeholders and support the residents more directly [20]. OSS has four different models – facilitation, coordination, all-inclusive, and ESCO model that differ on the level of responsibility in the energy retrofitting project. The evaluation of the different existing OSS organisations reveals the different underlying reasons to pursue the energy retrofitting project: public-driven organisations are focused on reducing energy consumption by the residents and the emissions at large, whereas private-driven OSS focus on the possible economic gains [21]. But with the newest business models, two of the most prominent social barriers – lack of trust and long decision-making process – cannot be tackled [20]. This shows the need to popularise solutions in which the resident is at the centre of each decision.

2.2. Building's Impact on the Resident / Energy Efficiency, Health, and Comfort

Energy poverty appeared as the dominant object of study that explored the link between the energy efficiency of households and health and well-being. Quantitative and qualitative methods and indicators or a combination can study energy poverty. The relevance of self-reported indicators, such as the ability to keep the home adequately warm, has been recognised. Well-being and health were identified as the areas of vulnerability factors. However, the relationship between energy poverty and health could not be found in the indicators considered by Costana-Rosa *et al*. A combination of the data about energy poverty percentage with the relation of household health can be done within the indicators such as 10 %, low-income high-cost indicator, and minimum income standard (MIS) indicator [22].

Energy poverty analysis can be done at different scales. Besides the national assessments, EU-level studies were conducted as well [23], [24] The European Quality of Life Survey is often

used for such assessments [25], [26]. The link between health and well-being and energy poverty was explored in 32 European countries. The predominant indicators used in the survey relied on the self-reported ability to afford energy and self-reported health status and mental well-being. In nearly all countries under examination, it was found that the energy-poor population reported more instances of poor health and well-being, with the highest rates in countries of Central and Eastern Europe. The disparities in poor health and well-being between energy-poor and non-energy-poor populations of one country can go up to around 46 %. In energy-poor countries, the likelihood of depression is bigger [25]. Another study looked at the energy poverty dynamics in the EU in the context of the financial crisis. Findings showed that energy poverty increased and declined during the economic crisis in the following years. The study similarly found that energy poverty is associated with poor self-reported health and well-being and depression [26]. Similar findings linking energy poverty with poor health and well-being appear in the studies focusing on vulnerable groups. The study in Barcelona evaluated the impact of the energy poverty of children based on the data from the National Health Survey completed by the children's caregivers. The study found that more than 10 % of children in Barcelona were living in energy poverty, which is strongly associated with poor mental and physical health and illnesses such as asthma and being overweight [24].

Energy poverty can also be understood from the assessment of vulnerability and prioritisation. Silvia Perez-Bezos *et al.* analysed 14 case studies of social housing in Bilbao. An energy poverty assessment graph [27] was used for the analysis that combined income/expenditure with building and country socio-economic and climate characteristics. The three-step method was used to assess the vulnerability to energy poverty. The adaptation of energy poverty assessment was made to reflect the context specificities, then the impact of the building's physical condition on the heating demand, and then prioritisation classification made to reflect to assess the vulnerability. Three vulnerability levels were distinguished after the analysis of 14 buildings. The year of construction and building compactness were important factors influencing the demand and final energy consumed for heating. The research recommended using energy poverty vulnerability assessments for a better policy design [28].

Another direction of research links energy efficiency and productivity. The study in Germany and Hungary quantified that living in high-efficiency buildings improves health and productivity, which can add up to 5.2 more productive days a year because of sick leave avoidance. Similarly, energy retrofitting may deliver up to 2.4 additional productive days annually. This increase in productive days results in an additional ten million EUR annually from residential and tertiary building sectors. Work performance can also be improved due to the avoidance of stress [29].

Energy use in buildings is also linked with the study of comfort in the literature, stressing to consider behavioural perspective while studying energy consumption. Comfort-making is motivated by striving for homeostasis linked with stress reduction and health improvement. The term ‘well-being’ can be better used in this context. Understanding comfort as IEQ was considered a narrow view that ignores people’s behaviour. Based on definitions from different disciplines, comfort can be seen as a variety of subjective reactions to environmental stimuli. The literature review of Ortiz *et al*. [30] found that people will seek comfort, and their actions will be well-being-driven. Achievement of well-being happens through the interaction with technology that creates energy consumption. Attitudes to energy and emotions shape the energy consumption patterns influencing the habits and actions of control. While habits are considered the main reason for the gap between predicted and actual consumption, it was proposed to address well-being and energy consumption from the user’s perspective. With the help of surveys, the needs, health, energy consumption habits, and expected level of control of the environment at home should be identified to recognise types of users and deliver better solutions for energy technologies and appliances [30].

2.3. Perception as an Indicator

Another direction of research focuses on tenant perception of the IEQ. The study from Sweden analysed the perception of IEQ in the 14 multifamily buildings. The post-renovation survey revealed that the residents were satisfied with the air quality, temperature, and noise level. An important aspect was the ability of tenants to control the IEQ. Most respondents perceived they had little control and that the IEQ remained unchanged after the renovation. However, 24 % of those who considered their flat too cold reported that IEQ improved after renovation. No association has been found between the perceived level of control of the IEQ and the perception of cold and drought [31]. Energy poverty research in Portugal through interviews revealed that the perception of thermal comfort may be influenced by the lowered expectations of what it should be and acceptance of the constraints that do not allow for the improvement of the situation. People exposed to low thermal comfort for a long time consider it a normal situation, contributing to the lack of recognition of energy poverty as a societal problem. However, the perceptions and expectations differ depending on the generation and education level. Households give more relevance to the price of energy rather than thermal comfort. Following the cheapest possible solution logic, some households focused on warming themselves rather than building [32]. Du *et al*. study confirmed the general agreement between the measured data on IEQ and residents' perception [18]. This shows the possibility of using the resident's perception as an indicative parameter for overall well-being assessment.

The research on perception also extends to renovation projects. Since residents have a very important role in renovation projects, their attitude to it attracted the research interest. Based on the experience of 3 multi-family renovation projects of social housing in Sweden, tenants' attitudes were allocated to six groups: satisfied, demanding, conservative, resigned, sceptical, and resistant. These conclusions have been made based on semi-structured interviews and field observations at the residents' meetings. Only two groups supported the renovation and recognised its benefits. The lack of information and understanding of renovation benefits, distrust of the information given, and fear of rising prices were the possible reasons for the dominant negative perception of the renovation project [33]. The study of the social aspects focused on residents' role in building renovation was also done in the Latvian context. The housing elders and residents of the renovated buildings were interviewed. Based on this, the necessity of well-informed residents and growing awareness of the wider benefits of renovation has been recognised [34].

The existing research shows the link between well-being, EPCs, energy poverty, and IEQ. Our study aims to consider all these aspects in four cities in Latvia due to the need for a resident-centred approach in evaluating ESCO services in the country.

3. METHODOLOGY

To explore the link between health, well-being, and energy retrofitting, the survey has been distributed among the households of 13 renovated multifamily buildings in three cities in Latvia. Buildings were renovated in the period from 2011 to 2020. The population of the study is 88 households. The sample represents 15.4 % of the population. The nonprobability or convenience sample was used, as the households replied to the survey voluntarily. Furthermore, the survey was anonymous and did not include demographic indicators; hence, the population was not stratified. The survey was conducted in two languages – Latvian and Russian.

The given methodology was selected to answer the research question because it offers a fast and convenient way for tenants to communicate their opinions. The practice of using surveys appears in

studies exploring the link between energy efficiency, well-being, and the socio-economic conditions of tenants [18], [25], [26], [31].

The limitations of the methodology include the sampling size. Ideally, the entire population would represent the sample. Also, as the surveys were completed voluntarily, the sample's responses can have bias, such as the households filling them could have a more positive attitude to the renovation process than on average of the population. More in-depth information could have been revealed with semi-structured interviews than surveys.

3.1. Survey structure and assessment

The survey consisted of 27 questions combining the perceptions of the IEQ and well-being, existing understanding of renovation benefits and works, socio-economic indicators, cost of renovation, and communication with other residents. [18], [20], [29]–[32]. The survey included closed questions, select-from-response options, and rating scale questions. The five-point scale was used. Most questions were rating scale questions, which are intuitive and easy to navigate. The average, minimum and maximum values and standard deviations were calculated for the obtained data to identify the resident perception.

The practice of using surveys appears in studies exploring the link between energy efficiency, well-being, and the socio-economic conditions of tenants [18], [25], [26], [31]. The data analysis of the socio-economic conditions was done using 10 % and over crowdedness indicators (see Eq. 1 and Eq. 2) The 10 % indicator implies that energy-poor households cannot cover adequate energy services with 10 % of their income. [35], [36] The potential economic benefits were not included as a separate question. Rather, the household's total income is revealed in the survey, which enables us to consider the 'eat or heat dilemma'. [22] The well-being was assessed based on three questions on a five-point scale [28].

$$\frac{\text{Cost of energy for household}}{\text{Income}} > 10\ \% \tag{1}$$

$$\frac{\text{Number of people in a household}}{\text{Number of rooms}} > 2 \tag{2}$$

The survey results were assessed to identify the perceptional patterns of the residents living in the renovated multifamily buildings to address the narrative created by such to the residents living in non-renovated buildings.

4. RESULTS

The sample size of 88 households represented 184 residents of the dwellings. Out of 88 households, 9 were considered overcrowded. The average net income of the households was 967.05 EUR, 27.71 EUR more than the average in Latvia [37]. The average monthly expenditure on utilities is 144.03 EUR, with 66 households spending more than 10 % of their net income.

In the questions related to the building assessment before the renovation, the overall score of the buildings was 2.70, which is described as 'worse than average'. The residents report a high level of interest in and the need for renovating their dwellings: they evaluated the need to renovate their buildings for 3.74 and overall interest as 3.93, both of which are within 'medium-high/high' levels. Before the renovation, 64.77 % of households communicated with their neighbours and perceived a 'medium-high/high' level of confidence in sharing their opinions on the state of the dwellings before the renovation, with an average score of 3.74.

In the evaluation of the renovation processes, the financial aspects of the project were ranked lower: the average response of the understanding of how the total cost of the project was calculated is 'worse than average', with a score of 2.84. The justification of the cost received a higher value of 3.39, between 'average' and 'medium-high'. Regarding the evaluation of the communication with the service providers, the ability to ask questions and the amount of information provided to the residents were evaluated as 3.26 and 3.13, respectively. The residents ranked the speed of the construction works as 3.5, which is a 'medium-high' score, and the quality of work as 3.25, which is between 'average' and 'medium-high'. The descriptors used for the renovation process are summarised in Fig. 1.

The evaluation of the state of the buildings after the renovation is 3.81, which is on the 'medium-high/high' level. The surveyed households report a decrease in communication with the neighbours after the renovation by receiving 2.98. Additionally, the perception of sharing a similar opinion about the state of the building decreased by 0.09 points. The residents report having additional ideas for the additional improvements of their buildings, with an average score of 3.07. Regarding the evaluation of expenses, the household's expenditure did not change significantly, with an overall score of 3.09, which is between the categories 'the same' and 'slight increase'. The current level of comfort, safety, and well-being of the residents was evaluated in the survey: the residents reported a high level of comfort and well-being with scores of 4.00 and 4.01, respectively, whereas the score for the level of safety is on the upper end of 'medium-high/high' with the average score of 3.92.

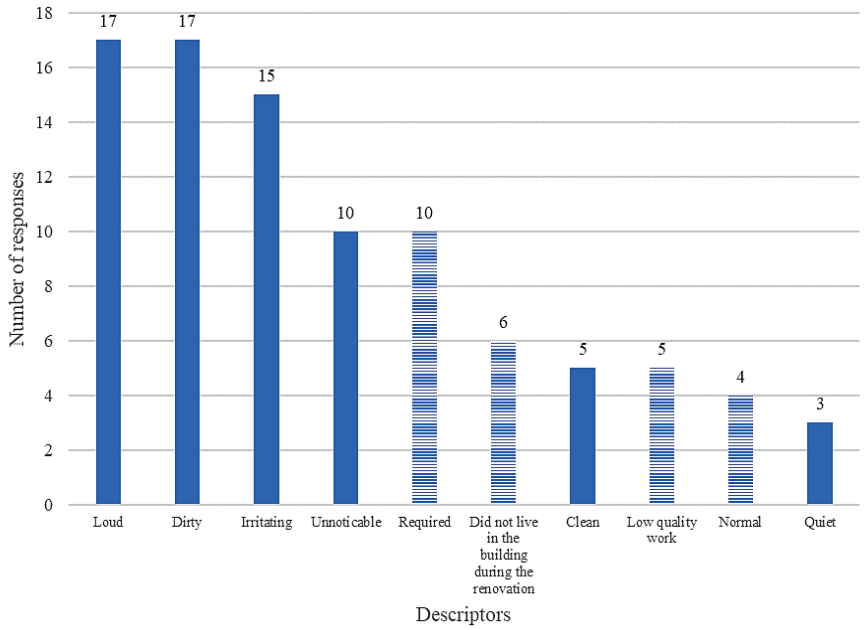


Fig. 1. The descriptors used for the renovation process (Note: the descriptors with the solid column colour were provided to the households in the survey, whereas the striped columns are the descriptors added to the answer 'Other').

5. DISCUSSION

The survey results revealed the tension created by the communication between the residents and service providers. Even if the project's cost seems justified after its completion, the need for understanding how the costs were created remains. This further amplifies the notion of the resident's disinterest in participating in energy retrofitting projects, which was identified by Latvian policymakers. But more crucially, this unwillingness is linked to the lack of communication from stakeholders, as revealed by the survey data.

The residents reported decreased communication after the renovation project was completed. Additionally, the perception that others share their opinion about the state of the building decreased. Both trends show that the energy retrofitting projects in Latvia cannot work as a community engagement instrument and may lead to a decreased sense of community among the residents. If the residents were more involved in the renovation process, their feeling of community and communication with other residents would improve. Being more engaged in the process would enable residents to be more united in their position, discuss their views and build the community.

The renovation process was evaluated as being 'loud, dirty, irritating' by most of the respondents. The given result is expected. However, the renovation needs to be less unpleasant for the residents. The negative perception of the building and renovation works during the process negatively affects the resident's well-being and the general narrative around the building renovation process. Ensuring a better view and perception of the process is important to encourage more renovations and improve the public image of such interventions. It is important not to discourage residents from the benefits of renovation due to negative attitudes towards the construction processes.

The safety, health, and well-being increased after the renovation process, which confirms that besides the physical improvements of the building, the residents are also positively affected by the renovation process. The residents value the increase of the metrics associated with their well-being, even though negative trends regarding the renovation were identified. The overall perception of the building quality increased, which shows the effectiveness of EPC+ contract implementation in Latvia, even though improvements in communication are required.

6. CONCLUSIONS

The paper considered the impact of renovation on the health and well-being of residents and the perception of the process done with EPC. The EU and Latvian policy actions to improve the conditions of building stock were discussed in the introduction. The literature review considered the effectiveness of the ESCO business models used in Latvia, the building's impact on residents, and the perceptions of the renovation process. The results revealed that the overall safety, health, and comfort level improved after the renovation, which confirmed the effectiveness of EPC+ use in Latvia. However, the evaluations of the renovation process show that the process perception as such, communication of the related costs, and the feeling of community among residents should be improved. The paper contributes to identifying and understanding the residents' needs in connection with building renovation process and shows the aspects in which it should be improved. The residents' willingness can scale up a better renovation process.

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