ENERGY EFFICIENT RENOVATION OF MULTI-APARTMENT BUILDINGS: MANAGEMENT, ECONOMIC AND ENGINEERING ASPECTS

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Abstract. The article analyses the results of the 2016-2023 national programme of multi-apartment building renovation in Latvia, being importantly co-financed by ERDF, and there was used the publicly available database of this programme implementation, as of 31st December 2023. This was complementary analysed during the six deep semi-structured interviews with main stakeholders and experts at the municipal level particularly. Valmiera city and county municipality was chosen for a case study as one of the most pro-energy active municipalities in the country, having developed and introduced a complementary set of energy governance instruments. The challenges are particularly related to the management and economic aspects and their interconnection with engineering ones as being identified. Within 2016-2023 in total around 22.8 thousand apartments (over 620 buildings) are renovated at national scale, however that is only around 4% of the total number of apartments. The planned thermal energy savings constitute around 0.9% of the total final energy consumption of the household sector in Latvia as being the high impact. High energy efficiency for heating is achieved in the renovated buildings (after renovation, the "B" energy efficiency class is achieved on average), however, the low number of renovated buildings still limits the impact of the programme. The renovation projects have a long (around 30 years in average) payback period, if compared with the actual district heating tariffs, thus, such renovation is hardly possible without the public grant part. Particularly, for completed projects in 2023 the specific costs significantly increase. The renovation of apartment buildings is analysed in the context of the energy citizenship (ENCI) concept. About 60% of building renovation are carried out by the legal institutional forms established by apartment owners, particularly, housing associations registered as NGOs. During the renovation of buildings, zero-emission decentralized energy production technologies are not installed until now, only few examples can be noted. Although the requirements of this renovation programme allowed, it could be assumed that the overall management and economic conditions were not enough attractive for the promotion of pro-sumerism for households or organizations to practice both - produce and consume energy.

Keywords: energy citizenship approach, Valmiera municipality specific savings, specific costs.

Introduction

The article deals with the challenges of multi-apartment building renovation, including implementation of energy efficiency improvement measures and installation of renewable energy production technologies (RET). The European Union (EU) climate-energy policy sets challenging targets. A highly energy efficient zero emission building stock should be achieved by 2050. In a medium-term perspective, the member states shall decrease primary energy consumption in buildings per 20-22% during the next decade (by 2035). The EU overall renewable energy target by 2030 is stated binding 42.5%, with the aspiration to reach 45% in gross final energy consumption. Latvia, contributing to EU collective efforts, should significantly increase the renewable energy share in final energy consumption, up to ~60% (2022 state – 43.3%), in its turn renewable energy share in buildings is envisaged 68% in 2030 [1].

The EU "Green Deal" actions, intended to increase the EU climate ambition and energy independence, are anticipated to lead to a complete transformation of the current energy system by funding innovative and practical technological solutions and empowering citizens to participate in the energy transition. Citizens are asked to play a more central role in achieving energy transition and are expected to change their lifestyles and behaviour, and participate proactively in the policymaking process [2] and in the prosumer practice.

Nowadays, a great share of citizens live in multi-apartment buildings, for instance, in Latvia the total number of households is around 829 thousand, of which 70.7% are apartments in multi-apartment buildings [3]. To contribute to transforming energy systems in case of living in multi-apartment buildings requires collective actions in scale of the building or in wider neighbourhood. In its turn, the energy citizenship (ENCI) concept is promising for cooperation. Regarding ENCI in the dwellings, previous studies on energy transition scenarios consider such ENCI types and forms as actions in households (e.g. [4-6]), energy communities (e.g. [7-10]).

A typical ENCI form is the collective decision for renovation of apartment buildings. Nowadays the "traditional" energy efficiency improvement of the building is/might be combined with installation of zero emission technologies, like rooftop solar energy technologies or heat pumps. Rooftop solar energy has huge untapped potential, as underlined by the EU Solar energy strategy.

Active renovation of multi-apartment buildings has started in Latvia in the EU Funds 2007-2013 programming period and thus now has already more than 15-year experience. In the article we analyse in detail the principal results of the renovation programme implemented in 2016-2023 (EU Funds 2014-2020 programming period) and administrated by the state-owned development finance institution – capital company "ALTUM" [11]. It should be noted that on December 8, 2022 the ALTUM started the implementation of a new support program for improving the energy efficiency of multi-apartment buildings and transitioning to the use of RET, financed by the Latvia's Recovery and Resilience Plan.

In Latvia most of the implemented projects relate to traditional activities of improvement the energy efficiency performance of apartment buildings. Although the installation of zero emission RET, like solar energy, by promoting decentralized energy production would contribute to the wide involvement of citizens in the energy system transformation processes, but currently being the week point for radically improving the renovation practice of the multi-apartment buildings in Latvia.

The technical possibilities of installing solar energy systems to renovate soviet type apartment buildings is analysed in depth in [12]. 5-storey, 9-storey and 16-storey buildings, built in Lithuania in the soviet era, are considered in this article providing conclusions both on energy production and engineering aspects. By computer simulation tools the authors determine the optimal technology combination – solar heat collectors for domestic hot water preparation and solar photovoltaic (PV) panels for electricity use – to achieve maximum energy benefits, actual collected heat and electricity consumption data is used for the analysis. One of conclusions, installing of 120 m^2 solar heat collectors (5-storey building roof) would cover around 61% of hot water preparation demand.

Researchers of the Institute of Physical Energetics have estimated that the total multi-apartment building rooftop solar PV technical potential might contribute 9-10% of the annual average (2018-2022) final electricity consumption in Latvia [13].

However, the ALTUM database [14] on multi-apartment building renovation projects, implemented in 2016-2023, indicates only two solar heat collector installation projects done together with the complex energy efficiency improvement of the buildings: the project in Valmiera city (16 apartment building, built 1960, 14.74 kW solar heat collectors installed) and the project in Riga city (7 apartment building, built 1898, around 11 kW solar heat collectors installed). Overall statistics on the installation of solar heat collectors in apartment buildings in Latvia are not available, some apartment buildings have installed solar heat collectors outside the EU funds programme as well, but it is clear that the number of these apartment buildings is low.

As another project providing essential lessons can be noted the installation of solar heat collectors for water heating in the municipal social house in Valmiera city. The reconstruction of the building was implemented in 2019. The building houses group apartments, a night shelter and a nursing home and is operated at the same intensity throughout the year [15].

Although in 2022 the concept of the renewable energy community (REC) and the principle operating procedures were included in the Energy Law and the Energy Market Law, a complete national legislative framework, by adopting detailed governmental regulations regarding energy communities, is still not completed. Therefore, RECs in multi-apartment buildings in Latvia are still in the embryonic development stage. Regarding solar PV, we can mention the pioneering example in Marupe municipality of installing a small capacity (1.32 kW_p) solar PV technology on the roof of a multi-apartment building to provide electricity for the consumption in common premises, this installation was done together with the installation of solar heat collectors (27 kW) for pre-heating hot water for the needs of all residents [16].

At the same time, we should point out the boom in solar PV installation in single-family buildings in Latvia that took place in 2022 and 2023. Starting practically from zero in 2020, at the end of 2023 the total number of household micro-generators (up to 11.1 kW) connected to the power distribution system was around 19 thousand with the total production capacity close to 160 MW. This rapid development has occurred due to factors such as the establishment of state support programmes, the availability of net metering systems for households and the significant increase in electricity prices in 2022, combination of which created high interest in self-production.

Therefore, there is an urgent challenge – how to develop the use of zero-emission RET in multi-apartment buildings, installing them at the same time as increasing the energy efficiency of buildings.

International experiences of multi-apartment building renovations

As presented above, the technical possibilities of installing solar energy systems to renovate soviet type apartment buildings are analysed in depth in [12]. The article [17] presents a case study of a renovated Swedish apartment building with a common design built in 1961. The building had an annual climate normalized district heat demand of 99.0 MWh before renovation and 55.4 MWh after, resulting in a 44% reduction. Judging from the results of this article, the planned thermal energy consumption for heating after renovation of building within the noted ALTUM administrated ERDF co-financed programme – approximately 54 $kWh \cdot m^{-2}$ per year (average baseline before the renovation – 128.4 $kWh \cdot m^{-2}$ per year) is quite optimal.

Several publications say to be careful when assessing ex-ante calculated energy savings. The article [18] analyses how well the energy performance targets are being reached following major energy efficiency-related refurbishment work on buildings, along with an analysis of the reasons for any differences. The research is based on the collected energy consumption level and indoor measurements. The authors constructed simulations of the indoor climate and energy use in 15 renovated apartment buildings. They found that in most cases the calculated heat energy consumption levels in the design phase were much lower than the measured values had shown. The authors discovered that re-simulated values with the same thermal transmittance values are, in most cases, up to 50% larger than the heating-related energy consumption levels in the design stage. From this knowledge, the authors can say that predictions for energy performance levels following refurbishment are too optimistic. The authors found the reason for heat energy consumption levels being higher following refurbishment work was due to higher indoor temperatures.

Article [19] discovered very high differences between calculated and actual energy savings, based on a field study that collected data on actual energy consumption over several heating seasons from 11 similar multi-apartment buildings in Poland. The actual energy savings range between 8.8% and 74.8% of calculated energy savings, depending on different renovations. Low results occurred in cases, e.g. where hydraulic balancing of the building internal heat supply system has not been performed adequately. Due to low energy savings, the payback time in **“**bad projects**”** exceeds even 100 heating seasons.

The process of renovation of multi-apartment building is very dependent on the resident involvement and participation practice. Unlike a single family building, in case of multi-apartment buildings the decision is the collective process in which each of the actors (owner of particular apartment) might have different initial considerations and motivations and the task is to come to a common decision acceptable for the majority. Previous cooperation (for instance, already well operating housing association) and local leadership existence play a crucial role.

Several recent articles discussed the institutional, education and other factors (besides investment co-financing) which promote renovation of apartment buildings. The attention is paid to the role of successful building renovation management.

The article [20] analyses household online survey data in Slovenia, August 2020. The authors conclude that high income levels, the fact that the respondent has taken a loan, the respondent age, the surface and age of the dwelling, previously performed retrofits, and the availability of subsidies are drivers, social capital facilitates the achievements. And opposite, in case of lack of social capital, the goals might be unattainable. The first step is fostering of good relationships and trust within an apartment building residents as it promotes easier agreements and facilitates coordinated actions. The second, better relationships with the building manager facilitate decision-making. The article argues for community-building as a tool for achieving better outcomes in residential energy efficiency measures. Community buildings can be started with a smaller-scale joint project, helping “create a sense of community and encouraging pursuing more ambitious projects later”. The authors believe that promoting and encouraging energy-saving behaviour through certain education and information measures and activities could lead to an increase in energy-saving habits, which in turn would have a positive impact on retrofits. The article highlights the need for a policy mix to address various aspects of energy efficient retrofit - education and information campaigns on the topics of residential energy efficiency, subsidies, preferential loans, tax rebates, and measures that concern the building's formal organization and foster community building.

The article [21] hypothesizes that the low retrofit rate of multi-apartment buildings in soviet-era countries could be partially explained by the low level of energy-related financial literacy among households. The article argues that this lack makes the households dependent on other essential stakeholders in the building retrofitting process. The empirical analysis relies on incentivized representative survey data collected from apartment owners in Lithuania. The authors found that energy-related financial literacy significantly increases apartment owners' willingness to retrofit the building. Also, the authors found that more trust in institutional stakeholders, in particular house administrators, significantly increased the apartment owners' willingness and concluded that providing both the costs and benefits of a particular building retrofit project in a clear, trustworthy, objective, and understandable manner should be taken as an important policy option. The authors propose that the opportunity to take a short, on-line or on-site, education and training on financial literacy, focused to costs-benefits, for apartment owners is an important action. The authors see the sharing good practice experiences among different communities as another way to overcome the shortages of knowledge and literacy. However, to facilitate such sharing, the relevant institutions that can be trusted by these communities are needed.

Results of [22] indicate that implementation of financial incentives in combination with informing and educating the public may have an important impact on future improvements in energy efficiency of homes. The role of a transparent and simple subsidy application procedure is underlined. Furthermore, the household response is clearly sensitive to the availability of subsidies, which implies that increasing funds, but, on the other hand, strengthening eligibility boundaries, would trigger more households' own investments resulting in the same level of public expenditure.

The intensive renovation of multi-apartment buildings and resulting decrease in the heat demand have to be linked with the adjustment of the district heating system capacity. The study [23] compares the investments made by heat consumers and by heat producers. It is found, to reach heat energy consumption for heating 60 $kWh \cdot m^{-2}$ per year, the specific investment per floor area made by consumers must be twice higher than that of heat producers: 220 $EUR \cdot m^{-2}$ *vs.* 110 $EUR \cdot m^{-2}$. As we found in our analysis, the noted consumer specific investment well coincides with the specific investments within the ALTUM administrated programme.

Approach and methodology

The renovation of the multi-apartment buildings was analysed in the context of the energy citizenship (ENCI) concept and as a part of the EU Horizon project EnergyProspects [24]. As outlined in this EU project the methodology for gathering comprehensive cases has been formulated to encompass and amalgamate various research interests and methodological needs. The methodology encompasses a database analysis and six deep-semi-structured interviews, when analysing the work and success stories of Valmiera municipality and its municipal enterprise working exactly with renovation of multi-apartment buildings. The results of the interviews are complementary with the database analysis and have been both incorporated within the national and local success stories.

To evaluate the results of the multi-apartment building renovation programme in 2016-2023, the database (EXCEL sheet) of the programme administrating institution ALTUM was used [14]. The database contains the principal information for each of the projects both completed and on-going implementation. However, the data base does not contain the summarised information which we consider is the novelty of the presented study. Direct information as well as the combination of information allowed to study the following key research questions related to exemplified aspects of management, economic-financial as well as engineering ones in their interaction:

1. scale of programme implementation – total number of apartments, total area of the building,
2. achieved total energy savings in the programme,
3. specific energy efficiency improvements in buildings – saved thermal energy and planned thermal energy consumption for heating after project implementation, $kWh \cdot m^{-2}$,

4. average specific costs from the resident perspective – EUR per apartment and per m^2,
5. specific thermal energy saving costs – EUR per 1 saved kWh, their breakdown by years of project completion,
6. detailed breakdown of energy efficiency improvement costs, depending on the year of the building construction, building type (construction series), number of apartments in the building,
7. project implementers – municipality housing company, resident collective forms (housing association, cooperative society), others.

Results and discussion

1. Financial resources for renovation of buildings – national and local level in Latvia

There are to be recognized five main sources of funding that can be involved in promoting energy efficiency in Latvia.

1. Investment support funds of the EU, particularly ERDF, with the aim of promoting the efficient use of energy resources in multi-apartment buildings. EU fund financing is used also for the improvement and modernization of the infrastructure of the city of Valmiera.
2. State support by attracting financial resources from the Ministry of Climate and Energy. This concerns public buildings, which have access to funds from the National Green Investment Scheme, namely, the Emission Allowances Auctioning Instrument (EAAI, revenues from the EU GHG emissions trading scheme). In 2022 the EAAI programme for residential sector has started as well, in 2023 this EAAI programme, initially intended only for single-family buildings and raw houses, was supplemented with multi-apartment buildings. Funding for energy communities is planned to be provided by the Multiannual Action Program of the Modernization Fund.
3. Municipal Grants for Investments in the residential sector**.** Several Latvian municipalities, including Valmiera municipality, provide co-financing not only for the development of technical documentation for building renovation (which is a traditional activity of Latvian municipalities) but also for investment grants, albeit in small amounts, for activities aimed at increasing building energy efficiency.
4. Private investments to cover the non-subsidized part of renovation. It should be noted that the average share of the ERDF grant in the completed projects within the analysed ALTUM administrated programme is slightly less than half of the total project costs (~47.2%).
5. State support by attracting financial resources from the Ministry of Environmental Protection and Regional Development, with the aim of developing the infrastructure of the city of Valmiera.

2. Renovation programme for multi-apartment buildings: nation-wide approach

In 2024, upon completion of the multi-apartment building renovation programme administrated by ALTUM, being co-financed by ERDF within the framework of the national operational program "Growth and Employment 2014-2020", 627 multi-apartment buildings will be renovated, including 22.8 thousand apartments (approximately 3.85% of the total number of apartments in Latvia).

2.1. Approaching management aspects frame

The total renovated area within the programme is 1.57 million m^3. Most of the renovated area is in the group of buildings with 31-60 apartments (41.8%) and with 61 + apartments (31.6%). A smaller contribution (25.3%) is provided by the group of buildings with 10-30 apartments. In its turn, the group of buildings with 3-9 apartments contributes very little to the overall results of the program, only about 1.3% of renovated area (it can be noted that this figure is significantly lower than the relative share of 3-9 apartment buildings (11%) in the total number of apartments).

Analysing 593 completed projects by the age (year of the first commissioning) of the renovated buildings, the largest renovated area (43%) is in the group built in 1961-1979, followed by the group built in 1980-1992 (33%). About 10 of the renovated area refers to other age groups. Unfortunately, the data is not complete due to ~14% of the renovated area does not indicate the year the buildings were commissioned.

Analysing the legal form of the authorized project implementer, ~57.3% of building renovations are carried out by apartment owners' established housing associations and ~2% by cooperative societies.

Thus, about 60% of building renovations are carried out by the forms of collective management of residents. Municipal housing management companies are important as well as authorized implementers of the renovation projects, contributing approximately 30% of the renovated buildings.

2.2. Approaching economic – financial aspect frame

The total cost of the completed projects (593 buildings) is approximately EUR 307 million. The selected technical-economic indicator is the specific cost (EUR) per 1 kWh of saved thermal energy for heating. In its turn, the specific costs per 1 m^2 of building's area and 1 apartment present the amount of investment that residents must invest.

There is seen a significant trend of increasing construction costs, especially in projects completed in 2023 (Table 1). It has to be noted the implementation of the projects may last for several years, and Table 1 indicates the completion year. Comparing the specific costs, $EUR \cdot kWh^{-1}$, with the tariffs of district heat supply in Latvian cities, it can be concluded that the investment has a very long payback period. So, for example, the final tariff of the Riga capital city district heating utility SC "Rigas Siltums" (*"Riga Heat")* in the 2023/2024 heating season for households was around 98 $EUR \cdot MWh^{-1}$ (with VAT). Compared to this tariff, the average payback time of the projects is 28 years, of the projects completed in 2023 – 35 years. It shows that the implementation of such renovation projects of more than 50% of thermal energy saving without the grant part of state/EU funds is practically impossible.

Table 1

Average specific costs of implemented projects within the programme depending on the year of project completion

Parameter	Unit	Average	Up to 2019 including	2020	2021	2022	2023
Number of buildings	number	593	106	81	67	72	267
Specific costs	$EUR \cdot m^{-2}$	207	150	179	171	95	247
	EUR per apartment	14 240	10 519	12 346	11 358	14 046	16 856
	$EUR \cdot kWh^{-1}$ saved	2.771	1.892	2.408	2.412	2.443	3.420

Resident costs, or costs per 1 apartment, increase significantly when the number of apartments in a building decrease, Table 2. Partially it can be explained due to the smaller buildings having higher relative share of non-residential area. These costs are very high for buildings with the number of apartments up to 9, which (partially) explains the low number of renovated such buildings.

Table 2

Average specific costs of implemented projects within the programme depending on the number of apartments in building

Parameter	Unit	Average	Number of apartments in a building			
			Up to 10	10-30	31-60	61+
Number of buildings	Number	593	43	257	214	79
Specific costs	$EUR \cdot m^{-2}$	207	358	230	213	173
	EUR per apartment	14 240	23 051	17 765	14 008	11 630
	$EUR \cdot kWh^{-1}$ saved	2.771	3.000	2.552	2.947	2.730

Especially in 2023, when the largest number of projects were completed, the average specific costs were lower in buildings with a larger number of apartments. The projects completed in previous years might show deviations from this conclusion: the buildings with smaller number of apartments may have lower costs of the specific savings due to the baseline being worse for them. The assessment of small multi-apartment buildings (3-9 apartments) is affected by the small number of renovated buildings in this group (Table 3).

Table 3

Average specific costs of thermal energy saving (EUR·kWh^{-1} saved) of implemented projects within the programme depending on the number of building apartments and project completion year

Number of apartments in a building	Parameters	Up to 2019 including	2020	2021	2022	2023
Up to 9	Number of renovated buildings	6	3	7	3	24
	Specific costs	1.733	1.880	3.042	2.291	3.650
10 -30	Number of renovated buildings	55	40	26	38	98
	Specific costs	1.754	2.168	2.160	2.204	3.500
31-60	Number of renovated buildings	31	28	25	29	110
	Specific costs	1.914	2.742	2.524	2,477	3.493
61 +	Number of renovated buildings	14	10	9	11	35
	Specific costs	2.061	2.282	2.499	2.685	3.198

2.3. Energy efficiency developments

The total thermal energy saving for heating planned *ex-ante* in the programme is 117 GWh per year. In the last 5 years (2018-2022) the average annual amount of district heat delivered to apartment buildings is around 4.34 TWh, thus the saving is around 2.7% of this figure.

The planned specific thermal energy saving for heating is 74.5 kWh·m^{-2} per year in average. Namely, the average calculated specific thermal energy consumption for heating before renovation is 128.4 kWh·m^{-2} per year, after the renovation it is planned to be 54 kWh·m^{-2} per year.

The average specific savings for heating differ significantly for groups of buildings according to the number of apartments: respectively 121.5 kWh·m^{-2} per year (3-9 apartment buildings), 90 kWh·m^{-2} per year (10-30 apartment buildings), 72 kWh·m^{-2} per year (31-60 apartment buildings) and 63 kWh·m^{-2} per year (61+ apartment buildings). For buildings with fewer apartments, the specific thermal energy savings for heating are higher due to the baseline for them being worse. So, for example, for 3-9 apartment buildings, the initial calculated specific consumption for heating is an average of 190 kWh·m^{-2} per year, while for 30+ apartment buildings it does not exceed an average of 125 kWh·m^{-2} per year. Considering the high initial energy consumption, the planned thermal energy consumption for heating after renovation is also higher for 3-9 apartment buildings, on average 68.5 kWh·m^{-2} per year (corresponding to energy efficiency class "C"); while for 31+ apartment buildings, the mentioned planned indicator is on average approximately 52 kWh·m^{-2} per year (corresponding to energy efficiency class "B").

Important to note, the planned specific consumption for heating is significantly lower than the value provided by the Cabinet of Ministers Regulation No 160 (2016, paragraph 31.3) on the implementation of the programme. Namely, the aforementioned regulation states that the renovated multi-apartment buildings should achieve ≤ 90 kWh·m^{-2} per year – this provision corresponds to the energy efficiency class "D". Also, the planned thermal energy consumption for heating of renovated buildings is more than 2 times lower than the "E" energy efficiency class (≤ 125 kWh·m^{-2} per year, if the heated area of the building is over 250 m^2), which is determined to be appropriate for existing apartment buildings.

It should be emphasized that approximately 55% of the completed projects do not specify the building series or are special projects. Analysing the completed projects by series of buildings, it can be concluded: (1) the planned after renovation specific thermal energy consumption for heating differs insignificantly; (2) the saving of the specific thermal energy consumption for heating varies between

57 kWh·m^{-2} per year (house model 104, analysed set of 11 buildings) – 78.5 kWh·m^{-2} per year (“Khrushchevka”: series 316 and 318, analysed set of 99 buildings), which depends on the baseline.

Table 4

Specific thermal energy consumption for heating of multi-apartment buildings of different construction series, kWh·m^{-2} per year

Specific thermal energy consumption for heating	“Khrushchevka” - 316 and 318 house models	Model 103	Model 104	Model 467	Model 602
Number of buildings	Set of 99 buildings	Set of 117 buildings	Set of 11 buildings	Set of 32 buildings	Set of 8 buildings
Calculated before project	132.5	128.6	107.6	113.1	117
Planned after project	54.0	53.1	50.5	52	50.1
Saving	78.5	75.5	57.1	61.1	66.9

The planned after renovation specific thermal energy consumption for heating differs insignificantly according to the legal form of the project implementer, varying within the limits of 51 kWh·m^{-2} per year (cooperative societies) – 54.6 kWh·m^{-2} per year (housing associations). It should be noted that housing association buildings have a relatively worse baseline (~134 kWh·m^{-2} per year), thus also the largest planned specific thermal energy savings for heating – 79 kWh·m^{-2} per year. For municipal housing companies managed buildings the mentioned indicators are respectively 120 kWh·m^{-2} per year (baseline) and 67 kWh·m^{-2} per year (saving).

3. Energy-efficient renovation of multi-apartment buildings at the local level

Coming down from national level directly to the local one, there was studied the case of Valmiera municipality, consisting of Valmiera city (around 23 000 inhabitants) and rural territories (parishes). Within the above described ALTUM administrated national programme there are 41 multi-apartment buildings renovated in Valmiera municipality – 36 buildings are located in Valmiera city and the infrastructurally nearby connected Valmiermuiza village (34 renovation projects completed as of 31.12.2023) and 5 buildings (all projects completed) in the rest of Valmiera municipality. There are 1436 apartments in the renovated buildings (1349 in Valmiera city and Valmiermuiza, but 87 in the rest of the municipality). The area of these renovated buildings contributes approximately 6.4% of the entire national area of renovated buildings.

3.1. Approaching management aspects locally

The total renovated area in Valmiera municipality is approximately 101 thousand m^2 (in Valmiera city and Valmiermuiza 95 thousand m^2; in the rest of Valmiera municipality - 6.1 thousand m^2). In Valmiera city (including Valmiermuiza) most of the renovated area is in the group of buildings with 31-60 apartments (49.3) and with 61+ apartments (36.6%). A smaller contribution (25.3%) is provided by the group of buildings with 10-30 apartments (12.3%). The group of buildings with 3-9 apartments contributes only 1.8% of the total renovated area.

Analysing the 34 completed projects in Valmiera city and Valmiermuiza, by the age (year of the first commissioning) of the renovated buildings, the largest renovated area (42% of the total renovated area, 12 buildings) is in the group built in 1980-1992, followed by the group built in 1961-1979 (33% of the total renovated area, 14 buildings). About 7.5% of the renovated area refers to other age groups. The data is not complete due to ~17% of the renovated area does not indicate the year the buildings were commissioned. Three 18-apartment buildings (built 1959, 1977 and 1984), one 8-apartment building (built 1928) and one 25-apartment building (built 1980) have been renovated in the rest of Valmiera municipality.

Analysing according to the legal form of the authorized project implementer, in Valmiera city and Valmiemuiza: (i) renovation of 20 buildings (or 55.5%) is carried out by the municipal housing management company "Valmiera Housekeeper, ltd." (*"Valmieras Namsaimnieks")*, (ii) 13 buildings (or 36%) are renovated by housing associations and 3 (8%) are renovated by cooperative societies. Thus, about 44% of building renovations (~47.3% of their area) are carried out by forms of collective management of residents. The renovation carried out by the form of collective management of residents is relatively evenly (3-5 buildings) divided by groups of buildings with different number of apartments.

3.2. Approaching economic-financial aspects locally

The total cost of the 39 completed projects in Valmiera municipality is around EUR 22 million. Similarly, as in the overall programme, also in the projects implemented in Valmiera municipality is seen a significant trend of increasing construction costs in the projects completed in 2023 (Table 5). As the general trend, the average specific costs are lower in buildings with a larger number of apartments (Table 6).

Table 5

Average specific costs of implemented projects in Valmiera city and Valmiermuiza within the programme depending on the project completion year

Parameter	Unit	Average	Up to 2019 including	2020	2021	2022	2023
Number of buildings	number	34	7	7	4	2	14
Specific costs	EUR·m^{-2}	219	175	183	238	220	251
	EUR per apartment	15 323	12 929	12 554	15 641	19 342	16 844
	EUR·kWh^{-1} saved	3.291	2.728	2.655	3.221	2.663	3.964

Table 6

Average specific costs of implemented projects in Valmiera city and Valmiermuiza depending on the number of building apartments

Parameter	Unit	Number of apartments in a building			
		Up to 10	10-30	31-60	61+
Number of buildings	number	5	9	15	5
Specific costs	EUR·m^{-2}	373	268	201	222
	EUR per apartment	23 038	16 948	14 434	17 276
	EUR·kWh^{-1} saved	3.657	2.734	3.090	3.824

3.3. Municipal energy efficiency developments

The total planned thermal energy saving for heating in the projects in Valmiera municipality is 7 GWh (approximately 6% of the entire ALTUM programme), of which 6.4 GWh in Valmiera city and Valmiermuiza and 0.6 GWh in the rest of Valmiera municipality.

In the projects implemented in Valmiera city and Valmiermuiza, the planned specific thermal energy saving for heating is ~67.5 kWh·m^{-2} per year in average. Namely, the average calculated specific thermal energy consumption for heating before renovation is 120.9 kWh·m^{-2} per year, after the renovation it is planned to be 53.5 kWh·m^{-2} per. In the five projects implemented in Valmiera municipality elsewhere, after the renovation the average specific thermal energy consumption for heating is planned to be 58 kWh·m^{-2} per year (the planned specific saving for heating is ~95 kWh·m^{-2} per year). The average specific saving for heating differs significantly for groups of buildings according to the number of apartments: respectively 113.5 kWh·m^{-2} per year (3-9 apartment buildings), 96.75 kWh·m^{-2} per year (10-30 apartment buildings), 65 kWh·m^{-2} per year (31-60 apartment buildings), 58 kWh·m^{-2} per year (61 + apartment buildings). For buildings with a smaller number of apartments the specific energy saving for heating is higher, because the baseline for smaller buildings has been worse. Thus, for 3-9 apartment buildings, the initial calculated specific consumption for heating is on average 185 kWh·m^{-2} per year, while for 10-30 apartment buildings – on average 155 kWh·m^{-2} per year, for 30+ apartment buildings – below 120 kWh·m^{-2} per year.

4. Valmiera municipal housing administration company – main local actor

In Valmiera, at the end of the 1990s and the beginning of 2000s, active privatization of apartments began, as a result of which many multi-apartment residential buildings belonging to the municipality came into the possession of apartment owners.

As a result of the reorganization, the municipality of Valmiera decided to establish a limited liability company, the charter capital of which is 100% owned by the municipality. And so, on February 13, 2001, the Limited Liability Company "Valmiera Housekeeper" (*"Valmieras Namsaimnieks")*, which is currently the leading house management company in Valmiera, started its activity. The company manages 94 multi-apartment residential buildings, 4 multi-apartment residential buildings belonging to the municipality, which cannot be transferred for privatization, and 14 multi-apartment residential buildings where apartment owners have not chosen a manager.

Within the analysed multi-apartment building renovation programme 2016-2023, "Housekeeper of Valmiera" carried out renovation of 20 multi-apartment buildings in Valmiera city and the structurally connected Valmiermuiza village. There are 757 apartments in the renovated buildings (approximately 56% of all renovated in Valmiera city and Valmiermuiza). The area of the renovated buildings – approximately 50 thousand m^2 or approximately 53% of the entire renovated area in Valmiera city and Valmiermuiza; this rate is higher than the average rate within the ALTUM administrated programme by municipal housing management companies. Most of the renovated area (57.8% of the renovated by the company area, 10 buildings) is in the group of buildings with 31-60 apartments. The next group of buildings is 10-30 apartment ones (6 buildings, 11.2% of the total renovated area). In the group of buildings with more than 60 apartments, 2 buildings have been renovated by the company (29.3% of the total renovated area). Two buildings have also been renovated by the company in the group of buildings with 3-9 apartments (1.7% of the area).

The total *ex-ante* planned annual savings of thermal energy for heating is 3.2 GWh, or approximately 50% of the total savings in Valmiera city and Valmiermuiza. Of them, 58.4% (~1.9 GWh) savings are provided in the group of buildings with 31-60 apartments, 24% (~0.8 GWh) – in the group of buildings with 61 + apartments, 15.6% (~0.5 GWh) in the group of buildings with 10-30 apartments and only 2% (~0.07 GWh) in the group of buildings with 3-9 apartments.

Analysing the projects implemented by "Housekeeper of Valmiera" according to the age (year of the first commissioning) of the buildings, the largest area of renovated buildings (38.8% of the total renovated area, 11 buildings) is in the group built in 1961-1979, followed by the group built in 1980-1992 (34% of total renovated area, 5 buildings). One of the renovated buildings was commissioned in 1960 (2.6% of the total renovated area), one in 1994 (7.4% of the total renovated area). For two buildings (17.3% of the total renovated area), the year of the first commissioning of the building is not specified. 10 renovated buildings are special projects, 5 buildings – series 103, and 5 buildings - series 316 and 318 buildings.

Table 7 presents (in a similar manner as the Tables 1 and 5 above) the average specific costs of the implemented projects by "Housekeeper of Valmiera" depending on the year of project completion. Again, the trend of increase of construction costs is clearly seen. The average specific costs per kWh saved thermal energy for heating for the groups of buildings with 10-30 apartments and 31-60 apartments renovated by "Housekeeper of Valmiera" are respectively 3.3 $EUR \cdot kWh^{-1}$ saved and 3 $EUR \cdot kWh^{-1}$ saved. It can be noted that the final district heat supply tariff for households of Valmiera city district heating utility is ~83 $EUR \cdot MWh^{-1}$ (with VAT).

Table 7

Average specific costs of implemented projects by "Housekeeper of Valmiera ltd." depending on the project completion year

Parameter	Unit	Average	Up to 2019 including	2020	2021	2023
Number of buildings	number	20	4	5	1	10
Specific costs	$EUR \cdot m^{-2}$	230	197	189	212	254
	EUR per apartment	15 194	11 859	12 053	14 091	17 303
	$EUR \cdot kWh^{-1}$ saved	2.771	1.892	2.408	2.412	3.420
Note: no projects completed in 2022						

Conclusions

Renovation of multi-apartment buildings in Latvia, co-financed by the EU funds (ERDF), started in 2009. Within two planning periods (2007-2013 and 2014-2020) around 1400 multi-apartment buildings are renovated. Particularly within the 2014-2020 planning period (implementation 2016-2024) around 620 buildings with around 22.8 thousand apartments are renovated (or around 4% of the total number of apartments). Although high thermal energy efficiency for heating is achieved in the renovated buildings (after renovation, the "B" energy efficiency class is achieved on average), the low number of renovated buildings still limit the impact of the programme.

1. 1. Namely, in overall in Latvia the average calculated specific thermal energy consumption for heating before renovation is 128.4 $kWh \cdot m^{-2}$ per year, after the renovation it is planned to be 54 $kWh \cdot m^{-2}$ per year. In the renovated buildings in Valmiera city these figures are 121 $kWh \cdot m^{-2}$ per year and 53.5 $kWh \cdot m^{-2}$ per year respectively.
2. 2. The planned heat energy savings constitute around 0.9% of final energy consumption of the household sector in Latvia. According the MURE (MURE – the database on energy efficiency policies and measures by EU countries) methodology such impact can be assigned as high impact measure.
3. 3, At the same time, such comparatively high energy saving has a long (around 30 years) payback period, if compared with the actual district heat tariffs for households. Thus, such renovation is hardly possible without ERDF grant part. Residents have to pay with a significant contribution of their own, even if almost 50% is co-financed by ERDF. In 2023, the construction costs significantly increased which resulted in increase of the specific costs per 1 m2 and per kWh saved, resulting in prolongation of the payback period.
4. 4. The group of buildings with 3-9 apartments contributes very little to the overall results of the programme, only about 1.3% of renovated area (having tenfold contribution in the total number of apartments in Latvia). Existing ERDF support conditions thus do not promote the participation of these buildings in the programme.
5. 5. Analysing the legal form of the authorized project implementer, about 60% of building renovation are carried out by legal forms established by the apartment owners, particularly housing associations which, according to the Latvia's legislation, are registered as the non-governmental organizations. Although it is not mandatory in Latvia to establish a registered housing association, established by apartment owners, the analysis shows that such a legal form facilitates the adoption of decisions on building renovations, especially if the residents already have a common practice of successful cooperation and joint decision making.
6. 6. Alternative to legal housing associations, as the implementer of the project is the renovation-building manager which is a municipal housing company, having crucial impact on the renovation development process in the case of Valmiera municipality. To a large extent, this alternative depends on the residents' trust in the municipal company and the existing cooperation practices. Particularly in Valmiera municipality, the municipal housing company implemented more than 50% of the renovated area and energy savings in Valmiera city demonstrating high resident trust.
7. 7. Analysing the spatial location of renovation projects in Valmiera municipality, only 12% of the projects have been implemented outside Valmiera city. This shows the need to promote the renovation of multi-apartment buildings also in villages/rural areas. Most of these rural area apartment buildings have relatively low apartment number (usually up to 20 apartments) and thus relatively high specific renovation costs. Effective tools are needed to promote renovation works in rural areas.
8. 8. Where Latvia lags behind is that the zero-emission decentralized energy production technologies are not installed until now during the renovation of buildings, only few examples can be noted. Although the conditions of the support program allowed, it could be assumed that the overall conditions were not attractive for the installation of such technologies. This issue shall be updated in the programme of the next 2021-2027 planning period.

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