T.Tamosiunas, K.Ciudaras; Vol.6.Iss.1. (Mar.2022) 30 - 42
https://doi.org/10.52576/TEMEL226.1030t

TEMEL-ij
Technology | Engineering | Management | Entrepreneurship | Learning | International Journal

RENOVATION OF ENERGY INEFFICIENT BUILDINGS IN LITHUANIA

Teodoras Tamošiūnas [1], Prof. Dr.,Vilnius University Šiauliai Academy, Lithuania

Corresponding Author, teodoras.tamosiunas@gmail.com

Kęstutis Čiūdaras, Master of Public Administration, Vilnius University Šiauliai Academy, Lithuania, kestasciu@gmail.com

Abstract: *Renovation of buildings is one of the priorities of the European Union's cohesion policy in the construction sector. The focus is on the renovation of multi-apartment residential buildings.*

Methodology of the research: the article analyses the content of scientific literature and documents on the renovation of buildings, summarises the statements of the performed empirical research – interviews of seven experts, the strategic directions based on the results of the research.

Main results. The analysis of the scientific literature enabled us to briefly formulate the concepts of passive or active building, to highlight the theoretical aspects of building renovation and the use of renewable energy sources. The analysis of the content of the documents showed the situation of Lithuanian buildings in the field of energy and the envisaged state plans for increasing the renovation of existing buildings. The suggestions made during the expert interview can be useful for improving the renovation processes of buildings. A strategic directions for renovation of existing buildings in Lithuania has also been developed and is based on the results of the research.

Key words: *renovation, energy inefficient building, active building.*

1. INTRODUCTION

Relevance of the research. Volvačiovas (2014) emphasized that the renovation (modernization) of buildings is one of the priority areas of the European Union cohesion

Corresponding author: [1] Teodoras Tamošiūnas, Prof. Dr.,Vilnius University Šiauliai Academy, Lithuania, teodoras.tamosiunas@gmail.com

TEMEL-ij
Technology | Engineering | Management | Entrepreneurship | Learning | International Journal

policy in the construction sector [1]. The energy efficiency of buildings and the parameters of the indoor microclimate are the most important reasons for society to renovate buildings. The renovation of multi-apartment residential buildings is the main source of public debate. According to the policy pursued by the European Union, energy efficiency in public buildings must be increased, energy efficiency requirements for buildings must be strengthened, and funding for the use of renewable energy sources must be increased. Renovation of buildings together with the improvement of the energy efficiency of the building increases the market value of the building, improves the aesthetic appearance, reduces the impact on the environment, prolongs the life of the building, improves the microclimate inside the building.

The problem of the research. Renovation of buildings has many goals, the implementation of which is measured by different indicators in various scientific sources and documents. Strategies for achieving goals and multi-objective decision-making methods also differ. Therefore, it is reasonable to raise *the problematic question* of the research: What criteria can be used to evaluate the results of increasing the energy efficiency of existing buildings in Lithuania?

Purpose of the article: after analysing the theoretical and documentary assumptions of increasing the energy efficiency of the construction sector, to form and substantiate the strategic directions for the renovation of buildings in Lithuania.

The research objectives: 1) to conduct an analysis of the scientific literature on the possibilities of the renovation of buildings; 2) to conduct the content analysis of the European Union and Lithuanian documents on the renovation of buildings; 3) to develop the methodology of empirical research – expert interviews; 4) to examine and summarize the results of the conducted expert interviews.

The theoretical contribution and practical implications. The article summarizes the theoretical and legal bases of renovation of buildings, highlights the essential possibilities of increasing his efficiency. Factual material of Lithuanian buildings in the field of renovation of buildings has been systematized. The statements summarized in the interviews of experts brought novelty to the topic of this field, their suggestions can serve to increase the renovation of buildings. A strategic directions for increasing the renovation of buildings in Lithuania, based on the results of the research, has been drawn up, it has been coordinated with the strategic documents of the Lithuanian construction sector and supplementing them.

TEMEL-ij
Technology | Engineering | Management | Entrepreneurship | Learning | International Journal

2. LITERATURE REVIEW

2.1. Passive and active buildings

A passive house is an energy-saving, ecological building that does not require a heating system or requires a very small amount of energy – on average about 10 percent of the energy consumed by inefficient buildings [2]. In passive buildings, the appropriate layout of the building, the use of solar, wind energy, geothermal sources, energy-saving household appliances, energy-saving lighting systems, etc. are selected [3]. Passive house operation can cost about 60–70 percent cheaper than a regular house. Passive houses can be autonomous: built independently of the existing infrastructure, engineering networks (electricity, gas networks, etc.), water supply, sewage treatment, rainwater disposal, communication service systems. Autonomous buildings have minimal impact on the environment. Passive houses have many advantages: savings in operating costs, energy independence, the comfort of the indoor environment, environmental friendliness [2].

An active house (energy plus house) is a building that produces more energy using special engineering systems than it consumes itself. The passive and active house has similar architectural planning and volume-spatial solutions. However, through energy equipment, they are equipped with satisfactory energy demand (a passive house) and generated energy excess (an active house). An active building is interoperable with the local and the entire energy system. Such a building must have the function of monitoring and analysis, and the ability to regulate load and export excess energy to the networks [4].

2.2. Renovation of buildings

New construction buildings in Europe account for a small proportion of all buildings, therefore, previously constructed buildings are a major energy consumer accounting for about 99 percent of the total energy consumption of the building sector. Therefore, renovation of buildings (modernization) is one of the priority policies of the EU construction sector [5].

One of the most popular ways to renovate a building is to insulate the building from the outside. Additionally insulated buildings have become more hermetic and their operational existence is increasing. Renovating the facade of the building also improves the aesthetic appearance of the building. To increase energy efficiency, high-quality thermal insulation is selected, windows with energy-saving glass packages, doors with good thermal insulation,

heating radiators with individual power regulators are installed. Heat loss of indoor ventilation is reduced by applying air preparation equipment with heat recovery – recuperator [5].

3. THE RESEARCH RESULTS

3.1. Improving the renovation of buildings: the content analysis of documents

In the EU countries, the annual rate of building renovation varies from 0.4 to 1.2 percent. In order to achieve the aims of energy efficiency and climate conservation of the European Commission in one of the six priorities of 2019 – 2024 foreseen in the document "The European Green Deal", this indicator will have to be at least twice as high. Presently, in the EU, 50 million energy consumers find it difficult or unable to heat their homes properly [6].

The goals of renovation in Lithuania are expected to be achieved through a comprehensive renovation of multi-apartment and public buildings, with priority given to the renovation of entire residential buildings rather than individual buildings [7].

The program of the Eighteenth Government of the Republic of Lithuania envisages a wave of renovation – 1000 renovated multi-apartment buildings per year. Conditions will be created for the quarterly renovation of residential buildings and the restoration of cultural heritage buildings. Until 2030, at least 15 percent of all construction works will be for the reconstruction of existing buildings. A construction code will be developed which will lay down clear and consistent rules for construction and the design and operation of buildings. From 2024, all public buildings will be built from at least 50 percent of organic and timber building materials. The use of secondary raw materials will be increased and construction waste will be reduced. The legal basis for the digital design processes of the construction process, buildings or infrastructure will be improved. Legal assumptions and tools for the construction process, building life cycle modelling and digitization will be developed. The aim is that 30 percent by 2025 and 50 percent by 2030 of the electricity consumed in Lithuania would be produced from renewable energy sources [8].

Lithuania's long-term renovation strategy (2021) emphasizes that as much as 78 percent of all buildings of the Lithuanian Building Stock are consumed by buildings of energy efficiency class lower than C, therefore, they are a priority for renovation. This strategy envisages a long-term vision for building renovation – to improve and transform the existing building stock. It is aimed that in 2050 this stock would be: 1) energy efficient (transformed

into a stock of energy efficient buildings); 2) independent of fossil fuels (with optimal fuel structure) [9]. This strategy must provide attractive conditions for the cost-effective conversion of existing buildings into nearly zero energy buildings.

3.2. Results of the expert survey

In order to interview the experts using the semi-structured interview method, a questionnaire was developed, consisting of 4 questions (see Table 1).

Table 1. Structure of the interview questionnaire

Renovation of energy inefficient buildings	1. Why the renovation (modernisation) of multi-apartment buildings is lacking behind compared to the planned numbers? 2. Are renovation procurement and project quality satisfactory for construction contractors? 3. What measures would you propose to increase the volume of buildings being renovated? 4. What measures can be most effectively applied to the use of renewable energy resources in existing buildings?

Source: compiled by the authors of the article

To conduct qualitative research, seven experts were invited. A semi-structured interview according to the compiled questionnaire was conducted in February 2021.

Seven highly qualified construction experts' statements on the renovation (modernisation) of energy inefficient buildings are categorised and representative statements made by several experts are provided in Table 2.

Table 2. Renovation (modernisation) of energy inefficient buildings

Category	**Representative expert statements**
Challenges of renovating energy inefficient buildings	When construction companies carry out renovation work, profits remain low or non-existent, and sometimes unprofitable. Ineffective state policy in the field of housing renovation. There is too little state incentive for the renovation of apartment buildings. The cost of renovation works is often too low to win a public tender. Such contractors do the work in poor quality after winning the competition.

	It is impossible to find qualified employees who would work at cheap rates. As a result, the quality of work suffers. Poor quality projects (investment plans and technical projects) cause construction delays.
Use of renewable energy sources in renovation	The most efficient installation of solar power plants or collectors for hot water preparation is on the roof of the building. The use of solar energy would pay off the most. The most likely to develop are those types of energy that are likely to be rewarding.
Technological and organizational factors	The technical design often provides for the cheapest technologies and materials, and therefore also affects the quality of the works. After renovation, many defects emerge, which are reluctantly returned to repair, and often there are no construction companies left. Insufficient quality of work due to lack of good specialists. If most employees are unskilled because a company is unable to hire qualified with winning job costs, then the quality of the work is also appropriate. Therefore, it is often returned after the renovation work to repair the defect. There is a lack of effective communication between all participants in the renovation process.
Desirable changes and proposals for the renovation of energy inefficient buildings	To increase state support for the renovation of multi-apartment buildings and other buildings. To introduce a pollution tax on inefficient buildings. Public authorities have to control more over the progress of renovation work. To address emerging and often recurring issues that hinder the renovation process more quickly. To change the procurement methodology used in the construction sector. To eliminate the cheapest tender criteria in public procurement. To purchase renovation services on the basis of criteria of economic utility only. To increase the responsibility of the designers for the quality of the technical project.

	To legalise that designers cover part of the losses if the contractor or the occupants of the house suffer from design errors.
Proposals for the use of renewable energy sources	To legally stipulate what percentage of energy would be produced from renewable energy sources after renovation. Renovation of buildings should make the use of renewable energy sources mandatory.
Suggestions for technological and organizational factors	To rely on examples of good renovation practices in EU countries that have proven successful in technology. The introduction of a builder's card would have a positive effect on the quality of construction work. An independent renovation coordinator is needed, under the authority of the municipal administration or another state organization, to control the renovation process. To implement measures to reduce errors throughout the renovation process.

Source: compiled by the authors of the article based on statements made during expert interviews

Summarizing the experts' statements, it can be emphasized that most of the experts singled out similar criteria describing the challenges of renovation (modernization) in the construction sector: the imperfection of public procurement when selecting a contractor for construction works on the basis of the lowest price criterion; insufficiently benevolent residents towards construction contractors; the delays in payment for the work performed; the low cost of the work, which makes it impossible to retain qualified specialists; poor quality of projects (starting with an investment, ending with a technical work project). Many errors or defects in construction work are caused by improper project solutions.

In the case of the renovation of energy inefficient buildings, experts consider it most appropriate to use solar energy from renewable energy sources. However, experts believe that the use of energy from other renewable energy sources also has prospects. As regards technological, organisational factors in the renovation process, experts stressed that there is often a lack of quality of work in the renovation of buildings.

Referring to the desired changes in the renovation of energy inefficient buildings, experts were unanimous on changing the procurement system: abolishing the cheapest tender criteria in public procurement and buying renovation works on the basis of purely cost-effective

criteria. Regarding the solution of design problems, experts unanimously agreed on the need to increase the responsibility of designers for the quality of projects.

As regards the wider use of renewable energy sources in the renovation of buildings, experts believe that indicators should be introduced to make the use of renewable energy sources in renovated buildings compulsory.

Technological and organizational factors that promote renovation, according to experts, should improve the attractiveness of renovation (modernization). Increasing public financial stimulus would make it easier to decide on the expediency of the renovation and make it easier for residents to bear the financial burden. An effective methodology for carrying out work and reporting should be developed. Most experts agreed on the need for greater control over technological processes during renovation work.

3.3. Strategic direction for renovation of buildings

The strategic direction for the improvement of renovation of buildings presented in Table 2 provides for the strategic objective of the improvement of renovation at the Lithuanian construction sector, its tasks and measures, as well as the applicable criteria for the evaluation of the achievement of the objective and criteria for the assessment of the outputs of the tasks. The direction was drawn up and, below Table 3, is based on facts and texts on the basis of the results of the research carried out by the authors of the article.

Table 3. The strategic direction for renovation of buildings in Lithuania

Objective: To improve the quality of renovation of existing buildings.	**Outcome criteria:** Change in greenhouse gas emissions from buildings. Part of renewable energy sources in final energy consumption for heating and cooling. Change in funding for building repairs.
Task 1: To increase the scope of renovation (modernisation) of existing energy inefficient multi-apartment buildings.	**Product criteria**: Proportion of renovated (modernized) energy inefficient residential multi-apartment buildings, in the percentage of all energy inefficient residential multi-apartment buildings. The part of renovated houses in the development of the quarterly renovation model in the total number of renovated houses. Use of renewable energy sources for building needs in percentage. Percentage of partial renovation from all buildings under renovation.

Task 2: To increase the scope of renovation (modernisation) of existing energy inefficient public, industrial, residential (individual) and other buildings.	**Product criteria:** Proportion of renovated (modernized) energy inefficient public, industrial, residential (individual) and other purpose buildings, in the percentage of all energy inefficient buildings of the same purpose. Use of renewable energy sources to meet the needs of the building, in percentage. Percentage of partial renovation from all buildings under renovation.
Measures: Ensuring continuous consultation, publicising renovation policies and good examples (effective communication). An integrated package of support measures for renovation. Optimal distribution of funding. Development of human resources competencies. Improvement of the Law of the Republic of Lithuania on Public Procurement. Strengthening of the responsibility for designing renovation projects.	

Source: compiled by the authors of the article based on the results of the research

The main challenge for improving the energy efficiency of buildings is the renovation (modernisation) of existing buildings. Therefore, the authors of this article also focused on the renovation of buildings in the development and justification of the strategic direction for the improvement of energy efficiency of buildings (see Table 3).

According to the data of December 31, 2020, provided by Real Property Register, 2.6 million units of buildings were registered in Lithuania with a total area of 235.3 million sq. m. Buildings subject to the requirements of the technical construction regulation relating to energy performance are relevant for the long-term renovation strategy. This building stock consists of 661 thousand buildings with a total area of 201.7 million sq. m. The major part of the stock's buildings consists of individual buildings – 529 thousand. There are 41 thousand multi-apartment buildings, 49 thousand industrial buildings and 42 thousand other non-residential buildings. Only 2 percent of buildings in the building stock (7 percent of the area) are public (municipal and state) property, i.e. only such part of the transformation of the building stock can be reliably planned and controlled by state institutions. The rest of the building owners have to make their own decision to take part in the renovation. 45 percent of the building stock by area consists of mixed ownership, i.e. both public and private and jointly owned. This fact can further complicate the decision-making process for building owners. 75 percent of the building stock area was built before 1992. At the end of the long-term renovation strategy (2050), the vast majority of the buildings in the stock will be over 60 years old and will require renovation [9].

TEMEL-ij
Technology | Engineering | Management | Entrepreneurship | Learning | International Journal

New construction buildings make up a small part of all buildings in Lithuania, and existing buildings are the main energy consumer. Renovation (modernisation) of buildings is one of the priority policies of the Lithuanian construction sector. Insulated buildings consume significantly less energy, they become more airtight and their life expectancy increases. When insulating a building from the outside, residents do not need to move out of the accommodation spaces.

Table 4 presents the projected indicators for the implementation of Lithuania's long-term renovation strategy.

Table 4. Indicators of the renovation strategy

Indicator	**Unit of measure**	**2021-2023**	**2024-2030**	**2031-2040**	**2041-2050**
Part of renovated buildings at the end of the period	percent	8 (in 2020)	17	43	74
Number of buildings renovated per year	units per year	8,086	10,717	15,614	18,059
Annual consumption of non-renewable energy sources (compared to 2020) at the end of the period	percent	95 (in 2020)	75	39	0
CO2 emissions (compared to 2020) at the end of the period	percent	100 (in 2020)	76	40	0
Consumption of inefficient (≤D class) buildings (compared to 2020) at the end of the period	percent	100 (in 2020)	77	45	12
Annual investments required for renovation	EUR million per year	867	1,286	2,071	2,767
Need for subsidies for renovation	EUR million per year	289	428	670	879

Source: (Lithuania's long-term renovation strategy, 2021)

Table 3 shows that the strategy envisages accelerating the pace of renovation and moving to energy efficient buildings by 2050, where the majority of energy consumption is from

renewable sources. Consumption of inefficient, less than Class D buildings in 2050 will account for only 12 percent of the number of buildings in 2020.

77 percent of the total CO2 emissions from the building stock come from buildings below the energy performance class C. As a result, residential buildings below the energy performance class C and all buildings using fossil fuels are seen as a priority segment of renovation for CO2 emission reduction [9]. Table 3 shows that CO2 emissions will be close to zero in 2050 after the renovation and transformation of the energy sector compared to 2020.

Lithuania's long-term renovation strategy provides for annual major investments necessary for the implementation of the renovation. About a third of investments will come from state subsidies (see Table 4).

In the program for increasing the energy efficiency of buildings, the authors of the article singled out the renovation of multi-apartment buildings as a separate task due to the special importance of the renovation of these buildings. By 2050, Lithuania will aim to renovate 30 thousand of apartment buildings, they will account for 74 percent of all apartment buildings. Although apartment buildings will account for only 7 percent of the total number of buildings under renovation, they will reach as much as 25 percent of the primary energy consumption and 24 percent of CO2 emission savings. After renovation and transformation of the energy sector, primary energy consumption of apartment buildings will decrease by 51 percent (the most inefficient apartment buildings – by as much as 93 percent). After renovation and transformation of the energy sector, CO2 emissions from apartment buildings will decrease to 0 percent [9]. Moreover, as mentioned above, apartment buildings have many co-owners, making it particularly difficult to reconcile renovation conditions with them.

4. CONCLUSION

Based on the analysis of the documents, it can be emphasized that renovation (modernisation) of energy inefficient buildings is the biggest challenge for Lithuania's construction sector, as existing capacities do not ensure the achievement of the goals set in the strategic documents of the EU and Lithuania. Only if all the renovation partners work smoothly and in accordance with common objectives the result will be achieved that will satisfy all parties. The use of renewable energy sources in the renovation process of multi-apartment buildings is insufficient.

TEMEL-ij
Technology | Engineering | Management | Entrepreneurship | Learning | International Journal

As the results of the interviews show, the experts unanimously acknowledged that the renovation (modernization) of energy inefficient buildings is necessary. However, experts have identified a number of challenges encountered in organising renovation processes: the unattractiveness of renovation in the construction sector is due to the imperfection of public procurement (selecting a contractor for construction works as a criterion of the lowest price); insufficiently well-intentioned residents towards construction contractors; delayed payments for the works done; low salary which makes it impossible to retain qualified specialists; poor quality of projects (from investment to technical work project). In order to improve the attractiveness of renovations in the construction sector, the following measures should be promoted: increasing public financial incentives for the population would make it easier to decide on the expediency of renovations and reduce the financial burden; an effective methodology should be developed to carry out works and payments; public procurement methodology should change; and responsibility for designers and experts should be increased for their activities. Experts emphasized that they wanted clarity in the development of the construction sector, to know what capacity would be needed in the future, especially in the face of the challenges of massive renovation of buildings.

REFERENCES

[1] Volvačiovas, R. (2014). *Investigation and Multi-Attribute Assessment into Efficiency of Public Building Renovation. Doctoral dissertation*. Technika, Vilnius.

[2] Rasiulis, R. (2017). *Building information modelling technology based model for renovation of administrative buildings assessment. Doctoral dissertation.* Technika, Vilnius.

[3] Mažulaitytė, G., Valančius, K. (2016). Nearly zero-energy residential home installation options in Lithuania. *Engineering Systems for Building. Proceedings of the 19-th Conference for Junior Researchers „Science – Future of Lithuania“,* 27-33.

[4] Strbac, G., Woolf, M., Pudjianto, D., Zhang, X., Walker, S., Vahidinasab, V. (2020). *The role of active buildings in the transition to a net-zero energy system.* A white paper on behalf of the Active Building Centre Research Programme, London Imperial College, Newcastle University.

[5] Mikučionienė, R. (2014). *Model of sustainable management of building energy performance characteristics. Doctoral dissertation*. Technika, Vilnius.

TEMEL-ij
Technology | Engineering | Management | Entrepreneurship | Learning | International Journal

[6] Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions, 11.12.2019 COM(2019) 640 final (2019). *The European Green Deal*. European Commission. Brussels.

[7] *Voluntary National Review on the Implementation of the UN 2030 Agenda for Sustainable Development in Lithuania* (2018). Ministry of Environment of the Republic of Lithuania. Vilnius.

[8] *Program of the Eighteenth Government of the Republic of Lithuania* (2020). Approved by the Seimas of the Republic of Lithuania in 2020 December 11 by resolution no. XIV-72. Vilnius.

[9] *Lithuania's long-term renovation strategy* (2021). Approved by the Government of the Republic of Lithuania in 2021 March 31 by Protocol Decision No. 18. Vilnius.