T.Tamosiunas, K.Ciudaras; Vol.6.Iss.1. (Mar.2022) 1 - 12
https://doi.org/10.52576/TEMEL226.1001t

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

MANAGEMENT OF ENERGY EFFICIENCY IMPROVEMENT OF BUILDINGS

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Abstract: *The article addresses the topical problem of the construction sector: improving the energy efficiency of buildings. 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 possibilities for increasing the energy efficiency of buildings in Lithuania. The article analyses the content of scientific literature and documents on the energy efficiency of buildings, summarises the statements of the performed empirical research – interviews of seven experts. The analysis of the scientific literature enabled us to briefly formulate the concept of energy efficient building. 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 energy efficiency of existing buildings. The suggestions made during the expert interview can be useful for improving the energy efficiency of buildings.*

Key words: *construction sector, building, energy efficiency, renewable energy sources.*

1. INTRODUCTION

Relevance of the research. The construction sector is extremely important for the state's economy, environment and society. The quality of buildings and their urban environment have a fundamental impact on the daily lives of every member of society. Construction creates an urban environment for the society. Binkytė (2018), based on research conducted in Lithuania and abroad, summarized that people spend about 80–90 percent of their time indoors, especially during the cold season [1]. This means that the quality of

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housing has a fundamental impact on the quality of life of residents. In her dissertation, Binkytė (2018) compiled a set of criteria for the assessment of safe and healthy housing and emphasized that indoor air quality is a key element in the energy performance of buildings.

The problem of the research. It is reasonable to raise *the problematic question* of the research: What are the tasks and measures to increase the energy efficiency of 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 possibilities for increasing the energy efficiency of buildings in Lithuania.

The research objectives: 1) to conduct an analysis of the scientific literature on the possibilities of increasing the energy efficiency of buildings; 2) to conduct the content analysis of the European Union and Lithuanian documents on the energy efficiency 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 energy efficiency of buildings, highlights the essential possibilities of increasing this efficiency. Factual material of Lithuanian buildings in the field of energy 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 energy efficiency of buildings. A strategic directions for increasing the energy efficiency 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.

2. LITERATURE REVIEW

2.1. Energy efficient buildings

The increasingly strict requirements of the European Union in the building sector require more efficient and ecological solutions for supplying buildings with energy, therefore, it is necessary to look for the best options for energy supply [2].

Directive 2010/31 / EU of the European Parliament and of the Council of 19 May 2010 (recast) on the energy performance of buildings (2021) requires that all new buildings from 2021 onwards must be *a nearly zero energy building* in the European Union, where

most of the energy consumed is from renewable sources. This directive states that, by 2010, buildings accounted for 40 percent of total energy consumption in the European Union [3].

In Lithuania, buildings or their parts are divided into nine classes according to energy efficiency: A ++, A +, A, B, C, D, E, F, G. Class A ++ is considered the highest. It is the most efficient building, consuming almost no fossil fuel energy, and most of the energy consumed is from renewable sources. Class G refers to an energy inefficient building that consumes a lot of fossil fuel energy. For newly constructed buildings for which an application for a permit to construct a new structure has been submitted after 1 January 2021, the energy efficiency class must be at least A ++. For buildings to be modernized from 1 January 2014, the energy efficiency class must be at least C [4].

Energy efficient construction has an ecological component that reduces the damage done to the environment and people and promotes the sustainable development of society as a whole. The majority of buildings built in Europe are residential buildings, which is why they have the greatest potential for energy savings [5]. Energy efficiency policies in the EU and other countries encourage an increase in the number of energy efficient buildings. Energy for heating new buildings is approaching zero, with ventilation, cooling and hot water systems consuming renewable energy sources becoming the dominant energy consumers [6]. Nearly zero energy buildings are high energy buildings where the majority of energy consumption comes from renewable energy produced locally or in the vicinity of these buildings. Properly designed and built nearly energy zero buildings (achieving A ++ class) is a challenge not only for Lithuania but also for the whole of Europe [7].

2.2. Use of renewable energy sources in buildings

When promoting energy production without harming the environment, the emphasis is usually on renewable energy sources –solar, wind energy, biofuels, hydropower, geothermal energy and biofuels [8].

The EU purposefully aimed to achieve at least 20 percent of all energy sources in the region by 2020. Lithuania's goal to reach 23 percent has already been implemented. One of the most popular renewable energy sources in Lithuania is wind. Wind energy is mainly used in the electricity, heating and cooling sectors, and to a lesser extent – solar energy. So far, the use of geothermal energy in Lithuania is low [9].

Summarizing Section 2.2, it can be stated that energy efficiency and reduction of natural source consumption are essential tasks for the modern design and operation of

building structures. Over the last decade, the EU has been pursuing a strategic energy efficiency policy that promotes the shift to renewable energy sources and the refuse of fossil fuels. In Lithuania, from 2021, all new buildings must be almost zero energy. They will have to comply with the A ++ energy efficiency class. Most of the energy consumed in such a building consists of energy from renewable sources produced locally or nearby. Lithuania mainly uses renewable wind and solar energy.

3. THE RESEARCH RESULTS

3.1. Improving the energy efficiency of buildings: the content analysis of documents

There are about 38 thousand multi-apartment buildings in Lithuania, about 60 percent of which are built between 1961 and 2000. At that time, the construction of typical brick and large-panel apartment buildings prevailed. The thermal resistance characteristics of their external partitions do not meet today's current regulatory requirements. Taking into account the energy consumption of heat in these buildings, there is a significant potential for energy saving in the implementation of energy efficiency measures in multi-apartment buildings [10].

Multi-apartment residential buildings (built before 1991) in Lithuania use the most, i.e. 54 percent of heat consumption of buildings. These buildings account for 60 percent of the stock of all Lithuanian buildings by occupied area. It is planned to reduce energy consumption in residential, public and corporate buildings. It is planned to increase the energy efficiency of buildings and to install facilities that produce energy from renewable energy sources that have less impact on air quality [11].

Innovative solutions and smart energy are the basis of Lithuania's sustainable economy. Companies are encouraged to use raw materials more efficiently and to optimize production processes, reduce the amount of waste generated and air pollution. Increasing energy efficiency is one of Lithuania's main strategic goals. To this end, it is necessary to further increase the share of renewable energy sources in Lithuania's domestic energy production and total final energy consumption, thus reducing dependence on fossil fuel imports. In the area of increasing the country's energy efficiency, it is planned that by 2030 the energy intensity of fossil fuels would be 1.5 times lower than in 2017 and by 2050 – about 2.4 times lower than in 2017 [12].

Lithuania has committed, together with the EU and its Member States, to reducing

greenhouse gas emissions by at least 40 percent over the period 2021 – 2030 compared to 1990. Changes are needed in the transport, energy and agriculture sectors. Energy consumption and efficiency improvement projects will be implemented. One of the main objectives of this program is to modernize buildings, promote the use of renewable energy sources and introduce environmentally friendly technologies (e.g. for the installation of biofuel boilers or solar power plants). The implementation of projects for the modernization of multi-apartment buildings and the increase of energy efficiency of municipal public buildings will be encouraged and supported. It is planned to provide training and education of participants in the process of increasing the energy efficiency of multi-apartment buildings and public buildings, as well as consulting on the preparation and implementation of investment plans [13].

3.2. The scope of experts and its justification

The selection of experts for the survey was aimed at ensuring not only their competence but also the diversity of the experts themselves, thus reducing the possible level of the subjectivity of the answers. Therefore, experts were selected from different ages and backgrounds, from different activities, with different experiences. Two experts were selected from the public sector and five – from the private sector. The selection of experts was subject to targeted selection. The experts were selected according to the following criteria:

- *management positions in the construction sector* – during the research, all experts held management positions (heads of departments, deputy heads of departments, managers of construction companies, construction managers of building, construction project managers). All selected experts are closely related to the construction sector by the nature of their work;
- *experience* – all experts have experience in the Lithuanian construction sector for at least 10 years;
- *higher education* – all experts have at least a bachelor's degree, some of them have a master's degree;

To conduct qualitative research, seven experts were invited. Their number was determined by the quality of the answers and the reached level of the results: while taking interviews from the sixth or seventh expert, many answers to the questions began to be repeated. The list of experts is presented in Table 1.

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Table 1. List of experts who took part in the survey

Responsibilities of experts	**Work experience in the construction sector (years)**
Member of the Lithuanian Association of Civil Engineers, Construction Director of a Construction Company	10
Head of the Municipal Administration Department	25
Deputy Head of the Municipal Administration Department	11
Head of the Construction Company	19
Head of the Construction Company	23
Head of a Building Construction of the Construction Company	24
Project Manager of the Construction Company	16

Source: compiled by the authors of the article

In order to interview the experts using the semi-structured interview method, a questionnaire was developed, consisting of 4 questions (see Table 2). As only a semi-structured interview was planned, the questions are indicative, providing only the direction of the discussion and can, therefore, be called guidelines. During the interviews, these questions were clarified, supplemented and the experts were given the opportunity to speak more widely than foreseen in the reference question.

Table 2. Structure of the interview questionnaire

Energy efficient buildings and the use of renewable energy resources in them	1. What are the challenges of building new A ++ buildings? 2. What factors encourage or hinder the construction of A ++ buildings? 3. What measures can be used most effectively to supply the building with energy from renewable sources? 4. What do you suggest, what trends do you forecast for the use of renewable energy sources in buildings?

Source: compiled by the authors of the article

The guidelines for the interview questionnaire were prepared on the basis of the analysed scientific literature and documents corresponding to the topic of energy efficiency of buildings. However, as already mentioned, the questions were supplemented and developed during the interviews, considering the statements of the experts. During the interview, it was aimed to reveal what the situation is now and what experts think should be done to change the situation. Questions were sent to all survey participants in advance so that

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the experts could get acquainted with the content of the questionnaire. A semi-structured interview according to the compiled questionnaire was conducted in February 2021.

3.3. Results of the expert survey

Seven highly qualified construction experts' statements on energy efficient buildings and the use of renewable energy sources are categorized and representative statements made by several experts are presented in Table 3.

Table 3. Energy efficient buildings and use of renewable energy sources

Category	**Representative expert statements**
Challenges of A ++ building construction	Construction of A + + buildings today is too expensive and difficult to afford. We should go back to the requirements to build Class A buildings, as they are much cheaper to build than A ++. Highly skilled builders are needed, as many construction technological things depend on human factors. Due to poor quality work, such a building may not receive an A ++ class certificate (tests are mandatory during certification).
Possibilities and challenges for the use of renewable energy sources	All renewable energy sources can be used for buildings, starting with solar, geothermal and other forms of energy. The most efficient thing to do is to use solar energy to produce electricity or prepare hot water. The use of geothermal energy requires large investments and can therefore be too expensive. The use of geothermal energy will increase if the equipment becomes cheaper. The hardest thing to do is adapt wind energy to buildings. The use of wind energy is problematic because of the noise generated by the power plants.
Technological and organizational factors	The quality of construction of individual buildings has deteriorated since the maintenance of the construction of the building is not mandatory. There are too few control mechanisms to ensure the quality of technological processes. Lack of experience in constructing A + + buildings. Adaptation of more sophisticated construction technologies is essential in the construction of A + + + buildings, and here everything is based on the need for higher qualifications and specialist knowledge.

	New effective insulation materials are needed, as the current insulation of the wall requires a layer about 40-50 centimetres thick to maintain the requirements.
Desirable changes and proposals for energy efficient buildings	Banks could extend the term of the loan on favourable terms. To lower the level of requirements from A ++ to Class A. To encourage the construction of energy efficient buildings through incentives (e.g. tax reductions for efficient and sustainable building materials). Faster development of new materials and technologies is needed to make the construction of these buildings less expensive.
Proposals for renewable energy sources	Promote the use of renewable energy sources in buildings at the state level. To foresee by the law that solar power plants should be installed on the roofs of apartment buildings.
Suggestions for technological and organizational factors	To restore the mandatory technical maintenance of building construction in the construction of individual buildings. To increase the requirements for the quality of work in the construction of energy efficient buildings. To develop new materials and technologies to thin the thickness of the insulation layer without deteriorating thermal requirements.

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

Summarizing the opinions of seven highly qualified construction experts, it can be emphasized that they unanimously stated that the construction of A ++ buildings will pose challenges to society due since it is significantly more expensive to build such a building. Such buildings will be difficult to afford and demand for them will not be high. The construction of A ++ buildings also poses challenges due to new technological processes and the need for qualified specialists. At the same time, however, experts acknowledge that energy efficient buildings are the most likely prospect for future housing.

The experts' opinion on the use of renewable energy sources in energy efficient buildings is positive enough, but the difficulties are also highlighted. Experts were unanimous in favour of the wider use of renewable energy sources in buildings, especially solar energy. The use of all types of renewable energy has a prospect. The most likely to develop are those types of energy from renewable energy sources that are likely to be rewarding.

The experts described what technological and organizational factors limit the construction of energy efficient buildings and identified what needs to be changed in these factors.

The experts indicated the changes they would like to see to make energy efficient buildings more attractive and made suggestions for the wider use of renewable energy

sources in energy efficient buildings. According to experts, the construction of A ++ buildings should be promoted at the state level and with financial resources. The wider use of renewable energy sources in meeting the energy needs of buildings should be encouraged by the state. Energy efficient materials and new technologies should emerge to facilitate the construction of such buildings. It is necessary to improve the control of the work carried out and to increase the quality of the work carried out.

3.4. Strategic direction for energy efficiency improvement of buildings

The construction sector in Lithuania is dynamic and changing. This sector faces major challenges, such as economic market fluctuations, increasing competition, tightening environmental standards, lack of human resources, and slow innovation. However, the Lithuanian construction sector strives to be an equal participant in the European construction market, competitive, stable, innovative and creating high added value.

The strategic direction for the improvement of energy efficiency of buildings presented in Table 2 provides for the strategic objective of the improvement of energy efficiency of 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 4, is based on facts and texts on the basis of the results of the research carried out by the authors of the article.

Table 4. The strategic direction for energy efficiency of buildings in Lithuania

Objective: To improve the energy performance 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 construction of energy-efficient apartment buildings.	**Product criteria**: Proportion of energy efficient residential multi-apartment buildings, in the percentage of all residential multi-apartment buildings. Use of renewable energy sources for building needs, in percentage.
Task 2: Tncrease the construction of energy efficient public, industrial, residential (individual) and other buildings.	**Product criteria:** Proportion of energy efficient public, industrial, residential (individual) and other purpose buildings, in the percentage of all buildings of the same purpose. Use of renewable energy sources to meet the needs of the building, in percentage.

Measures: Ensuring continuous consultation, publicising construction policies and good examples (effective communication). An integrated package of support measures for construction. 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 construction projects.

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

In Lithuania, it is planned to develop electricity generation from renewable energy sources (wind and solar). The aim is to achieve 30 percent by 2025 and 50 percent by 2030 of the country's electricity consumption that would be derived from renewable sources. The target is for one in three households to produce and accumulate electricity for their own use in Lithuania by 2030 [11].

Attitudes towards solar energy are improving every year. Residents are interested in solar collector systems and their benefits. Faster development is hampered by the relatively high cost of these systems and long payback times. Investment in renewable energy technologies is often not very attractive for businesses. Greater public support is therefore needed to make these technologies competitive [14].

4. CONCLUSION

The results of the analysis of theoretical sources highlight that energy efficiency and the reduction of the use of natural resources are essential tasks for the design and operation of building structures. Construction of A + + buildings is today's challenge of adapting new technologies to the construction process. Such buildings are referred to as passive or almost zero energy buildings. Most of the energy consumed in such a building comes from renewable energy produced locally or nearby.

Summing up the statements made by experts during the interview, it can be emphasized that in the construction sector, the use of innovations and advanced technologies is a key force for increasing the productivity of the sector, promoting effective competition and attractiveness of workplaces. The constantly increasing demands for quality of construction and rapid work are factors that make the construction sector change in technological terms and seek unconventional solutions.

It is appropriate to discuss with the members of the Seimas of the Republic of Lithuania about such proposals for improving the energy efficiency of buildings: to amend the Law of the Republic of Lithuania on Public Procurement. The transition to higher quality

evaluation criteria must be encouraged, and to use less frequently the lowest price criterion in the selection of companies (design, construction, etc.) for the implementation of construction projects. New methodologies need to be developed for public procurement in the construction sector, such as cost-efficiency criteria, green, sustainable criteria, etc. It is appropriate to introduce more safeguards in public procurement conditions, such as average salary of employees in the company, fulfilment of warranty obligations, good feedback from former customers, fulfilment of health and safety requirements at work, etc.

The proposals addressed by the authors of this article to the Ministry of Environment of the Republic of Lithuania are debatable: to effectively address the problems of the construction sector in crisis situations or in conditions of economic uncertainty due to the COVID-19 pandemic. With the declining volume of construction in Lithuania, it is necessary to increase construction work orders from the public sector by investing in the development or renewal of infrastructure (communications, engineering communications, etc.), renovation (modernization) of state and public buildings, etc.

In addition, the responsibility of designers and experts who carry out project expertise on the quality of construction projects should be increased. A compensation mechanism needs to be set up when the errors of designers or project experts cause damage to construction companies and customers. It is appropriate to develop a methodology that clearly defines the liability for compensation of affected parties.

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