THE 20TH EDITION OF THE INTERNATIONAL CONFERENCE
EUROPEAN INTEGRATION
REALITIES AND PERSPECTIVES

Energy Performance of Buildings Through Economic Efficiency

Svetlana Albu[1], Ion Albu[2]

Abstract: Ensuring the energy performance of buildings is essential for social resilience and sustainable communities. Achieving the required performance is possible by implementing different energy efficiency measures. The basic principle for identifying and prioritizing potential energy efficiency measures and renewable energy sources is "ensuring maximum utility at minimum cost". This means ensuring thermal comfort in rooms, providing the required level of artificial lighting and meeting the required level of sound insulation through recommended energy efficiency measures. The aim of the research is to develop and provide a practical methodological tool to support pre-investment decisions on energy efficiency projects for buildings. The research focuses on the national normative-methodological framework in correlation with the international one. Various research methods are applied such as analysis and synthesis, comparative analysis, mathematical and statistical calculation methods. Conclusions are verified through case studies. The outcome of the research allows building owners and managers to identify energy efficiency measures according to their financial resources, to prioritize them and to substantiate the decisions they receive.

Keywords: buildings; energy efficiency; costs; prices; investment

JEL Classification: O18 Urban, Rural, Regional, and Transportation Analysis, Housing, Infrastructure

1. Introduction

One of the ways to ensure social resilience, sustainable development of communities is to ensure the energy performance of buildings. Achieving the necessary performance is possible through the implementation of different energy efficiency measures. Energy efficiency is defined as "the ratio between the result obtained in the form of services, goods or energy and a given amount of energy used to achieve that result (Parliament of the Republic of Moldova, 2018). Thus, when referring to buildings, energy efficiency in buildings means the ratio between personal comfort/social utility and the amount of energy required to provide it. In other words, "the amount of energy calculated or measured to provide the energy required in normal (standard) use of the building, which includes, inter alia, energy used for heating, cooling, ventilation and air-conditioning, domestic hot water preparation and lighting" is

[1] Dr.Hab., Technical University of Moldova, Chisinau, Moldova, Address: 168 Stefan cel Mare Av., Chisinau, Republic of Moldova, Corresponding author: svetlana.albu@emi.utm.md.
[2] PhD, Technical University of Moldova, Chisinau, Moldova, Address: 168 Stefan cel Mare Av., Chisinau, Republic of Moldova, E-mail: ion.albu@fcgc.utm.md.

Copyright: © 2025 by the authors.
Open access publication under the terms and conditions of the
Creative Commons Attribution-NonCommercial (CC BY NC) license
(https://creativecommons.org/licenses/by-nc/4.0/)

considered by national legislation as the *energy performance of the building* (Parliament of the Republic of Moldova, 2023).

The state policy in the field of energy performance of buildings, among others, also aims to achieve the following objectives: mobilizing investments in the renovation of existing buildings; promoting an increase in the number of buildings whose energy consumption is close to zero; promoting cost-effective measures to improve the energy performance of buildings (Parliament of the Republic of Moldova, 2023). These ideas are also reflected in the sectoral strategy for the long-term renovation of the national building stock, which is concretized in the National Integrated Energy and Climate Plan (NIECP) 2025-2030. The PNIEC was approved by the Government on February 26, 2025 and foresees the renovation of residential buildings with financial support from the Fund for Energy Efficiency in the Residential Sector (FEERS), as well as energy savings of 0.8% of the average annual consumption as a result of the implementation of energy efficiency measures and new efficient technologies, the installation of smart meters and the promotion of clean and energy efficient transport (Ministry of energy of the Republic of Moldova, 2025).

2. Related Work

The energy performance of buildings is addressed at international level, in particular by three key EU directives: the Energy Efficiency Directive (European Parliament, 2023), the Energy Performance of Buildings Directive (European Parliament, 2010), and the Renewable Energy Sources Directive, which have been transposed into national legislation. (Parliament of the Republic of Moldova, 2018; Parliament of the Republic of Moldova, 2023; Ministry of energy of the Republic of Moldova, 2025)

The level of energy performance that results in the lowest cost over the remaining design lifetime of the building is *the cost-optimal level*. The national legislative framework (Parliament of the Republic of Moldova, 2023) states that the lowest cost shall be determined taking into account energy-related investment costs, maintenance and operating costs, including energy costs and savings, the category of building concerned, the energy revenue generated, or taking into account the costs of demolition/dismantling of a building element, as appropriate. The standard service life of the building shall be laid down in the building normative documents. This refers to the remaining rated operational lifetime of a building, where the energy performance requirements are set for the building as a whole, or to the rated operational lifetime of a building element, where the energy performance requirements are set for the building elements.

The cost-optimal level lies in the range of energy performance levels where the cost-benefit analysis, calculated over the remaining standard service life of the building, is positive.

The costs of potential energy efficiency measures and renewable energy sources have a complex structure. According to the regulatory framework of the Republic of Moldova, the initial basis for determining the value of the necessary investments, forming the value of the contractor contracts, making settlements for the construction-assembly works performed, payment of expenses for the purchase of equipment and its transportation to the construction site and for other expenses on the account of the means provided for in the general estimate is the estimate value (Ministry of regional development and construction, 2012, pp. 3-4). The method of determining the estimate value is regulated by a number of normative acts and practical guides (Ministry of regional development and construction, 2012; Ministry of regional development and construction, 2022; Ministry of regional development and construction, 2005).

3. Problem Statement

The implementation of energy efficiency measures requires the identification of concrete measures and related investment costs. The basic principle for identifying and prioritizing potential energy efficiency measures is "ensuring maximum utility at minimum cost". Maximum utility means ensuring thermal comfort in rooms, providing the required level of artificial lighting, and meeting sound insulation levels through recommended energy efficiency measures.

The optimal correlation between investment costs and ensuring maximum utility depends on the current physical condition of the building, the building materials used and the technological solutions of the engineering systems accepted at the building construction stage. Thus, in some cases it may be sufficient to replace windows and doors, while in other cases complex measures are needed to ensure the maximum usability of the spaces. The selection of the optimal correlation is possible through the economic evaluation of energy efficiency measures, which not only ensure the maximum usability of the rooms but also reduce the maintenance costs of the building.

The practical problem lies in the complexity of the calculations and analysis needed, both technical and economic, in order to recommend optimal solutions for owners. The research is costly and time-consuming, resources which at the pre-investment stage are not justified.

4. Concept and Terms

In order to ensure energy efficiency (EE) and harness renewable energy sources (RES) in the Republic of Moldova, measures are recommended: legislative, technological, and building materials, systems, and equipment (Table 1).

Table 1. EE and SER measures recommended to the residential sector in the Republic of Moldova

Measure	Category
Energy audits	Legislative measure
Energy performance certificates	
Thermal insulation of external walls	Technological measures and building materials
Thermal insulation of the roof	
Basement insulation works	
Replacement work on windows and exterior doors: PVC windows PVC doors	
Works for energy efficiency of interior lighting: LED luminaires	
Energy efficiency works in outdoor lighting: LED luminaires Meters / monitoring systems	
Valorization of renewable energy sources: Photovoltaic systems Evacuated tube solar collectors Air-to-water heat pumps Solid biomass heating plants Hybrid photovoltaic and thermal solar panels Ground source heat pumps	Systems and equipment
Thermal energy efficiency works: Thermal points Condensing central heating systems (including room thermostat) Thermal insulation of heat supply pipes Horizontal distribution systems Replacing radiators (including thermostat valves)	
Works to make ventilation and air conditioning systems more efficient	

Source: based on Parliament of the Republic of Moldova, 2023; Albu and Panevski, 2024; Albu and Panevski, 2023.

5. Solution Approach

In order to simplify the decision making process regarding the selection of energy efficiency measures for buildings, it was proposed to apply the "puzzle" principle, focused on ensuring the minimum level of energy performance at acceptable investment costs for the beneficiary.

The investment required (estimated value) for the implementation of the building renovation project comprises several cost elements.

Equation 1.

$$I = VLC + VLM + PU + AC$$

Where: VLC - the value of construction works; VLM - the value of assembly works; PU - the price of the machine; AC - other expenses.

The value of construction works VLC and assembly works VLM includes the cost of labor, materials used, operation of machinery, as well as overheads and the benefit of the estimate.

The category 'other costs' covers additional costs: for the transportation of workers, travel expenses, etc.; technical supervision; the cost of design work; author's inspection; expert appraisal of feasibility documentation, project documentation and estimates; advance payment; and includes the contingency reserve.

Developing cost estimates for renovation projects in existing buildings involves considerable effort, time and cost. In order to simplify the process of estimating investment costs, based on energy efficiency measures, it has been proposed to apply indicators by categories of works (ICW). The national regulatory framework allows their application, specifying that LCWs "shall be developed for construction works and erection works on the basis of typical building design solutions and repeated use of individual economic projects. LCWs are established for separate construction elements for categories of works and devices of the object. LCWs contain in their composition indicators of consumption elements in value and resource structure" (Ministry of regional development and construction, 2012, p. 32).

The cost indicators have been determined for works that provide acceptable energy efficiency according to national standards. The LCWs for construction and erection works comprise the following categories of expenditure: value of materials, including transportation and purchase-storage costs; payroll costs, including social and health insurance; operation of machinery.

6. Analysis of Results

The algorithm for estimating the value of the energy efficiency project was developed in excel and 76 indicators were calculated by categories of works necessary to increase the energy efficiency of buildings. The inclusion of LCW in the algorithm allows immediate determination of investment costs.

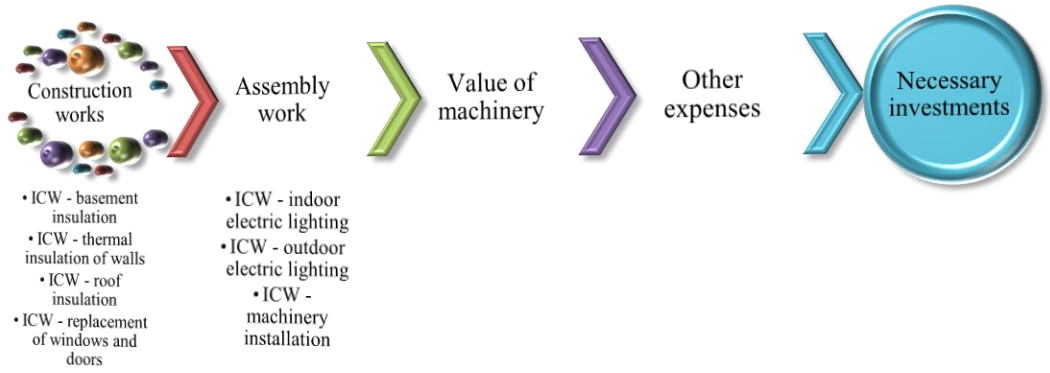

Figure 1. Energy efficiency project value estimation algorithm

The value indicators have been developed in Q2 2023 prices, and inflation already does not allow their direct application. In order to be able to use the indicators at any point in time, the methodology of updating them by indexing direct costs was proposed. For this purpose, the structure of LCW was calculated in three categories: labor, materials, machinery and equipment (Figure 2). Indexation is proposed by applying the indexes calculated on the basis of data provided by the National Bureau of Statistics.

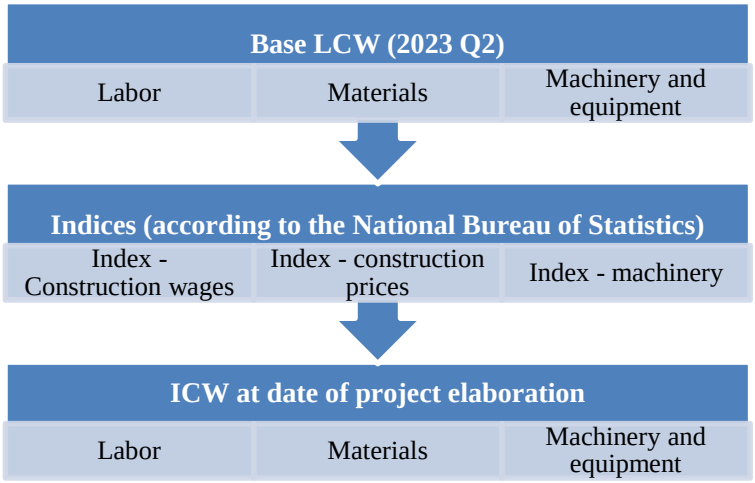

Figure 2. Updating the LCW at the date of energy efficiency project development

The results obtained were compared with the actual investment costs of energy efficiency projects implemented in the Republic of Moldova. The correspondence with actual market values was demonstrated.

7. Conclusion

The proposed methodology allows to simplify and cheapen the research work of energy auditors, it allows to substantiate the pre-investment decisions of owners / managers of residential blocks or public buildings. The transposition of the proposed algorithm into excel format ensures

- Cost estimation of recommended technical solutions;
- Determination of the value of investments necessary to implement the energy efficiency project;
- Selection of the most efficient package of solutions.

Future Work

In this study, indicators have been developed for polystyrene and mineral wool insulation works. Value solutions in the "economical" and "medium" categories that ensure the minimum level of energy performance of buildings were selected. We consider it appropriate to develop LCWs for other types of insulating materials in order to offer a wider range of technical solutions that will increase the energy efficiency of buildings and ensure the sustainable development of localities.

Acknowledgement

The research methodology was developed within TUM research sub-program 020408 Research on Ensuring Sustainable Development and Increasing Competitiveness of the Republic of Moldova in the European Context.

The value indicators were developed within the framework of CNED projects with the financial support of UNECE and UNDP.

References

Albu, S., & Panevski, S. (2023). *Guidelines for implementing energy efficiency measures and harnessing renewable energy sources for public sector buildings*. Retrieved from https://cned.gov.md/sites/default/files/document/attachments/ghid_pentru_implementarea_masurilor_de_eficienta_energetica_si_valorificarea_surselor_de_energie_regenerabila_pentru_cladirile_din_sectorul_public.pdf.

Albu, S., & Panevski, S. (2024). *Guidelines for implementing energy efficiency measures and utilization of renewable energy sources in the residential sector*. Retrieved from https://cned.gov.md/sites/default/files/document/attachments/ghid_ee_imobile_locative_.pdf.

European Parliament. (2010, May 19). *Directive 2010/31/EU of the european parliament and of the council on the energy performance of buildings*. Retrieved from https://eur-lex.europa.eu/eli/dir/2010/31/2021-01-01.

European Parliament. (2018, December 11). *Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources*. Retrieved from https://eur-lex.europa.eu/legal-content/RO/TXT/?uri=celex%3A32018L2001.

European Parliament. (2023, September 13). *Directive (EU) 2023/1791 of the european parliament and of the council on energy efficiency and amending Regulation (EU) 2023/955 (recast)*. Retrieved from https://eur-lex.europa.eu/legal-content/RO/TXT/PDF/?uri=CELEX:32023L1791.

Ministry of energy of the Republic of Moldova. (2025). *National Integrated Energy and Climate Plan approved by the Government*. Retrieved from https://energie.gov.md/ro/content/planul-national-integrat-pentru-energie-si-clima-aprobat-de-guvern.

Ministry of regional development and construction. (2005, June 1). *CP L.01.06-2005 Construction economics. Instructions on the preparation of estimates for adjustment-demand works by the resource method*. Chisinau, Republic of Moldova.

Ministry of regional development and construction. (2012, April 1). *CP L.01.04-2012 Construction economics. Instructions on the determination of the estimated costs of operating construction machinery*. Chisinau, Republic of Moldova.

Ministry of regional development and construction. (2012, August 1). *CP L.01.08-2012 Construction economics. Instructions on the determination of expenses for the maintenance of the beneficiary service*. Chisinau, Republic of Moldova.

Ministry of regional development and construction. (2012, February 1). *CP L.01.02-2012 Construction economics. Instructions for the determination of estimating costs in construction payroll*. Chisinau, Republic of Moldova.

Ministry of regional development and construction. (2012, January 1). *CP L.01.01-2012 Instructions on the preparation of estimates for construction-assembly works by the resource method*. Retrieved from https://ednc.gov.md/cp-l-01-01-2012/.

Ministry of regional development and construction. (2012, January 1). *NCM L.01.01-2012 Construction economics. Rules for determining the value of construction objectives*. Retrieved from https://ednc.gov.md/ncm-l-01-01-2012/.

Ministry of regional development and construction. (2012, July 1). *CP L.01.07-2012 Construction economics. Instructions on the determination of the value of purchase and storage costs in construction*. Chisinau, Republic of Moldova.

Ministry of regional development and construction. (2012, March 1). *CP L.01.03-2012 Construction economics. Instructions on the calculation of overheads when determining the value of objectives*. Chisinau, Republic of Moldova.

Ministry of regional development and construction. (2012, May 1). *CP L.01.05-2012 Construction economics. Instructions on the determination of the value of the benefit of the cost-benefit in the pricing of construction output*. Chisinau, Republic of Moldova.

Ministry of regional development and construction. (2022). *Amendment CP L.01.02:2012/A2:2022. Instructions for determination of the estimate expenses in construction payroll*. Chisinau, Repbulic of Moldova.

Parliament of the Republic of Moldova. (2018, July 19). *Law No. 139 on energy efficiency. (O. G. 309-320/2018, Ed.)*. Retrieved from https://www.legis.md/cautare/getResults?doc_id=144980&lang=ro#.

Parliament of the Republic of Moldova. (2023, October 5). *Law No 282 on Energy Performance of Buildings. (O. G. 401-403/2023, Ed.)*. Retrieved from https://www.legis.md/cautare/getResults?doc_id=147677&lang=ro#.