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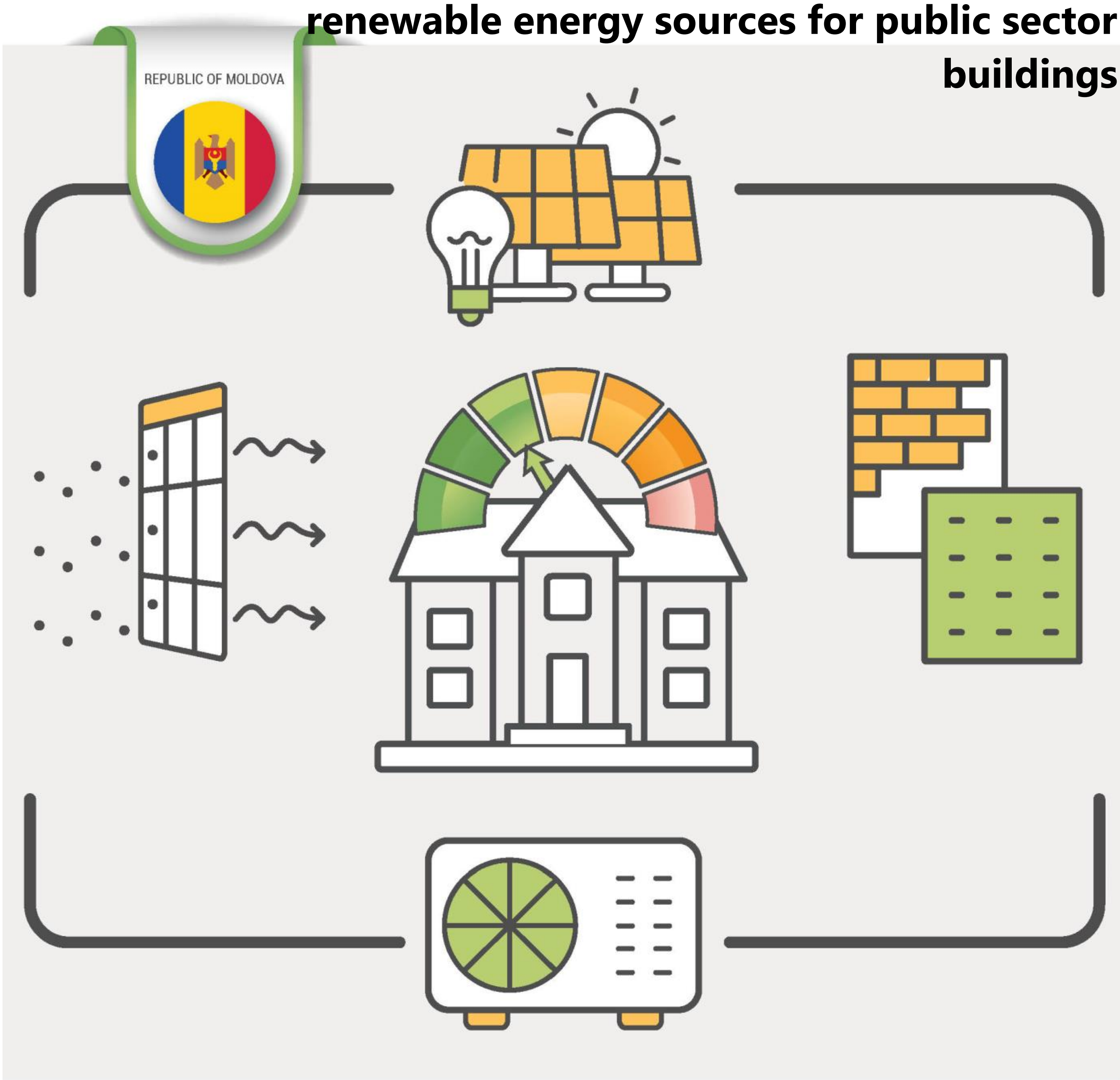
Guide for the implementation of energy efficiency measures and valorization of renewable energy sources for public sector buildings



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Acknowledgments

Svetlana Albu and Sashe Panevski are the main authors of this report. Aleksandar Dukovski, Grigore Vascan and Doina-Cezara Albu provided support in research and in drafting this report. Oleg Dzioubinski, Igor Litvinyuk, and Gianluca Sambucini of the UNECE Sustainable Energy Division contributed to the report through their review and comments. Valuable contributions to the report were provided by the following experts: Denis Tumuruc of the Energy Community Secretariat, Manole Balan from the Energy Efficiency Agency, Valerian Colun and Lucia Arseni from the Ministry of Energy of the Republic of Moldova.

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List of Acronyms

A	Discount rate
CF	Cash Flow
COP	Coefficient of performance
CPC	Code of Practice in Construction.
CRI	Composite Resource Indicators
CRN	Composite Resource Norms
CS	Costs in Service
CVIC	Composite Value Indicators for the Construction of Buildings and Special Constructions
E	Economic effect
EBRD	European Bank for Reconstruction and Development
EE	Energy Efficiency
EED	Energy Efficiency Directive
EER	Energy Efficiency Ratio
EnCS	Energy Community Secretariat
EnCT	Energy Community Treaty
EPBD	Energy Performance of Building Directive
EPC	Energy performance certificate
EU	European Union
EUR	Euro
GD	Governmental Decision
GEFF	Green Economy Financing Facility
HDD	Heating Degree Days
HVAC	Heating, Ventilation and Air-conditioning
I	Investment effort
ICW	Indicators for Categories of Works
IEA	International Energy Agency
IFI	International financial institutions
ISO	International Standardisation Organisation
K	Commitment capital
LEAP	Local Energy Action Plan
LED	Light-Emitting Diode
Low-E	Low emissivity
MNC	Moldovan Normative in Construction
n.d.	No Date
NAS	National Accounting Standards
NBMA	National Building Management Authority
NBS	National Bureau of Statistics of the Republic of Moldova
NEEAP	National Energy Efficiency Action Plan
NGO	Non-governmental organization
NPV	Net Present Value

NZEB	Nearly zero energy buildings
O&M	Operation and Maintenance
PV	Photovoltaics
PV - T	Photovoltaic - Thermal Hybrid Systems
RES	Renewable energy sources
RESD	Renewable Energy Sources Directive
RoI	Return of Investment
RoM	Republic of Moldova
RPTC	Regular Programme of Technical Cooperation
SDG	Sustainable Development Goals
SEC	Specific energy consumption
SEER	Seasonal Energy Efficiency Ratio
SM	Moldovan Standard
T	Payback period
TC	Total Cost
TDC	Total Discounted Cost
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UPS	Uninterruptible power supply
VAT	Value Added Tax

Currency (12.08.2023)

lei/USD	17,74
lei/EUR	19,56

List of signs and measures

%	Per cent
°C	Temperature in Celsius degrees
1/h	Air exchanges per hour
cm	Centimetres
CRI	Color rendering index
d	Thickness in meters
De	Period of economic use of the building
e	Efficiency of the investment
E	Economic effects
E'h, I'h	Discounted values of annual economic benefits and annual investment tranches
HDD	Heating degree days
I	Investment effort
K	Temperature in Kelvin
kg/m3	Kilogram per cubic meter
kPa	Kilopascals
ktoe	Kilotons of oil equivalent

kW	Kilowatt
kWh/KWp	Kilowatt hours per kilowatt power capacity
kWh/m2	Kilowatt hour per square meter
kWh/year	Kilowatt hours per year
lei/m2	Moldovan lei per square meter
lei/unit	Moldovan lei per unit of equipment
lm	Lumens
lm/W	Lumens per watt
lux	Illumination
m	Meters
m2	Square meters
mm	Millimetres
R	Thermal resistance
t	Time period
T'	Dynamic payback period
TJ	Tera Joule
U	Heat transmission through a building part
W	Watt
W/m²K	Watt per square meters per Kelvin
W/mK	Watt per meter per Kelvin
λ	Thermal conductivity

Number formats

,	Thousands separator
.	Decimal separator

Executive summary

The study "Guide for the implementation of energy efficiency measures and valorization of renewable energy sources for public sector buildings" is structured to give support of the efforts of the Government of the Republic of Moldova to improve energy efficiency and increase share of renewable energy resources in response to the energy crisis, as well as support of the implementation of the RPTC-funded study "Guide for the implementation of energy efficiency measures and the valorization of renewable energy sources for public sector buildings". As target buildings, public buildings are considered, such as schools, kindergartens, hospitals, and cultural centers.

This study is intended for those responsible for ensuring energy efficiency in public buildings in central and local public administrations. The guide can be used in the process of preparing the pre-feasibility study to identify energy efficiency measures and assess the investment costs depending on the measures selected and the financial resources available.

The guide provides recommendations for energy auditors on how to select and justify energy efficiency measures for public buildings.

The study is structured in three main parts that give overview of the existing situation, such as the legislation and statistics for energy consumption in buildings, then it defines the necessary measures for energy efficiency and utilization of renewable energy sources, together with their technical characteristics, and ends with estimation of the values of the measures and their construction cost index.

The Moldovan legislation is recognizing the importance of a favorable legislative and regulatory framework to enhance energy efficiency (EE) and harness the potential of renewable energy sources (RES); thus the Republic of Moldova (RoM) has taken steps to align its primary legislation with EU directives. This was a requirement after joining the Energy Community Treaty in 2009.

In view of the energy consumption of buildings, they represent 58 percent of the total final energy consumption in the country. Furthermore, the non-residential buildings account for 17 per cent of the stated consumption. In addition, the buildings have high specific energy consumption. For example, the specific energy consumption of hospitals is 326 kWh/m^2, while the educational buildings have specific energy consumption of 199kWh/m^2. This is higher than the European average and energy efficiency measures are necessary in order to improve the buildings' comfort for the users and reduce the energy bills.

In order to achieve the minimum requirements for performance and improve the comfort of the buildings, three sets of measures are proposed: legislative measures like energy audits; technological measures and building materials like thermal insulation of the buildings envelope elements, replacement of doors and windows, energy efficient lighting systems and monitoring systems; and systems and equipment like change of the energy source (replacement of boiler with heat pumps) utilization of renewable energy and improvement of the heating system.

Several solutions for each defined measure are elaborated, together with list and volume of work, as necessary to define the construction cost index (ICW - indicators for categories of works). The algorithm for calculating the investment value (costs) according to the selected measures is developed and the method for updating the ICW in current prices at the date of the pre-feasibility study or energy audit report is proposed.

Indicators for assessing the economic efficiency of energy efficiency measures specific to public buildings are proposed.

As a conclusion several guidelines are offered, based on the findings of the study:

- **Procurement**. Integrate energy efficiency criteria into public procurement practices, encouraging the purchase of energy-efficient equipment and materials for government buildings.
- **Regular Energy Audits.** Conduct regular comprehensive energy audits of the buildings to identify areas of inefficiency and potential energy-saving opportunities as well as to create regular action plans in the buildings.
- **Training and Capacity Building.** Invest in training and capacity building for government personnel and facility managers to improve their understanding of energy efficiency technologies and practices would result in better operation and maintenance, as well as better energy management and reduced bills.
- **Energy Management Systems.** Regularly monitor energy consumption, assess the impact of implemented measures, and adjust strategies for continuous improvement. Develop and promote energy management programs for public buildings, including benchmarking energy performance against similar buildings to drive continuous improvement.
- **Data Collection and Reporting.** Establish a centralized database to collect and analyze energy consumption data from public buildings, enabling informed decision-making and policy evaluation.
- **Renewable Energy Targets.** Set renewable energy targets for public buildings and provide support for the integration of renewable energy systems, such as solar panels or geothermal heat pumps.
- **Public Awareness Campaigns.** Engage building occupants through awareness campaigns and education on energy-efficient practices, encouraging them to adopt more sustainable behaviors. Launch public awareness campaigns to educate building occupants and the community about energy efficiency, encouraging responsible energy use.
- **Prioritize measures.** Consider that the measures are interconnected. For example, before changing the energy generation, first lower the energy demand. That way, the new system for energy production will be properly optimized.

By adopting these guidelines and recommendations, buildings can take a systematic and holistic approach to energy efficiency, starting with the optimization of the building envelope and gradually incorporating renewable energy solutions as needed. This approach often leads to more cost-effective and sustainable outcomes in the long run.

Introduction

The study "Guide for the implementation of energy efficiency measures and valorization of renewable energy sources for public sector buildings" is structured to give support of the efforts of the Government of the Republic of Moldova to improve energy efficiency and increase share of renewable energy resources in response to the energy crisis, as well as support of the implementation of the RPTC-funded study "Guide for the implementation of energy efficiency measures and the valorization of renewable energy sources for public sector buildings". Its goal is to provide:

- An overview of the provisions of the primary and secondary normative framework regarding the requirements and the need to implement energy efficiency measures and the use of renewable energy sources in public buildings. It should highlight the important aspects regarding the implementation of state policies in the field of energy efficiency and the use of renewable energy sources at the local level.
- Identify technical requirements regarding the implementation of efficiency measures and the use of renewable energy sources in public buildings in accordance with the provisions of the technical regulatory framework in construction, as well as the standards in the field.
- Develop recommendations regarding the selection and prioritization of potential energy efficiency measures and the use of renewable energy sources that can be implemented.
- Develop recommendations regarding the performance of the energy audit, for the required sector and recommendations regarding the selection of specialists responsible for performing an energy audit (Register of energy auditors).
- Develop description of the principles for developing a project proposal in the field of energy efficiency and renewable energy sources in the buildings sector.
- Provide estimates of unit costs for the main energy efficiency measures and utilization of renewable energy sources to be taken into account when developing project proposals related to public buildings. When estimating the unit costs, all the activities necessary for the implementation of the measures, especially those of energy efficiency, will be taken into account, respecting all the necessary technological processes, according to the provisions of the construction regulations in force.
- Provide presentation and individual description of energy efficiency measures and renewable energy sources that can be implemented in public buildings, including the description of the technical-economic evaluation methods for determining the feasibility of their implementation.
- Provide presentation and individual description of energy efficiency measures and renewable energy sources that can be implemented in public buildings, from the point of view of the execution of the works and the monitoring of the correct execution of the modernization works.
- Develop recommendations regarding the management and proper functioning and maintenance of the objects after the implementation of energy efficiency measures and installation of renewable energy equipment.

Chapter I. Overview of legal framework for energy performance of buildings and use of renewable energy sources

Primary legislation

Recognizing the importance of a favourable legislative and regulatory framework to enhance energy efficiency (EE) and harness the potential of renewable energy sources (RES), the Republic of Moldova (RoM) has taken steps to align its primary legislation with EU directives. This alignment was a requirement upon joining the Energy Community Treaty (EnCT) in 2009. The primary legislation pertaining to EE in buildings is closely tied to three key EU Directives: The Energy Efficiency Directive (EED), the Energy Performance of Buildings Directive (EPBD), and the Renewable Energy Sources Directive (RESD). These directives have been transposed into national legislation through the following laws:

Law No. 139 of 19.07.2018 on energy efficiency (***amended by Law No.113/2023)***: Law No. 139, enacted on July 19, 2018, holds immense significance as a horizontal legislative act that serves as a catalyst for promoting energy efficiency across all sectors, with particular emphasis on buildings. This legislation lays down the foundational principles of the state's energy efficiency policy, many of which have a direct impact on the buildings sector. By aligning with the EE Directive, Law No. 139 encompasses various key elements, including the formulation and implementation of an Energy Efficiency Strategy, the annual renovation requirement of 3 per cent for centrally owned and occupied buildings, the introduction of EE obligation schemes, integration of energy efficiency considerations in public procurement processes, and the facilitation of energy services promotion.

By incorporating the principles outlined in the EE Directive, Law No. 139 establishes a robust framework that drives energy efficiency practices in the buildings sector. The development and adoption of an Energy Efficiency Strategy outlined in the law provide a comprehensive roadmap for achieving energy efficiency objectives in Moldova. This strategy acts as a guiding document, enabling policymakers and stakeholders to prioritize and implement effective measures to enhance energy efficiency in the building sector.

Furthermore, the law emphasizes the importance of annual renovation activities, mandating that 3 per cent of centrally owned and occupied buildings undergo renovations each year. This requirement reflects the commitment of the Republic of Moldova to modernize and upgrade its building stock, resulting in improved energy performance and reduced energy consumption. By addressing the energy efficiency needs of public buildings, Law No. 139 sets a precedent for sustainable practices and serves as an example for private entities to follow suit.

The introduction of EE obligation schemes under this legislation is another significant step toward achieving energy efficiency goals. These schemes incentivize and promote energy efficiency measures by imposing obligations on energy suppliers, distributors, and consumers. By implementing such schemes, Moldova encourages stakeholders to actively engage in energy efficiency practices, leading to reduced energy consumption and carbon emissions.

Law No. 139 also recognizes the importance of energy efficiency considerations in public procurement processes. By integrating energy efficiency requirements into procurement procedures, the government ensures that energy-efficient products and services are prioritized. This provision not only encourages the use of energy-efficient technologies and solutions in public buildings but also sets an example for private entities to adopt similar practices.

Lastly, the law underscores the significance of promoting energy services as a means to enhance energy efficiency. By encouraging the utilization of energy services, such as energy audits, energy management systems, and performance contracting, Law No. 139 creates a conducive environment for the implementation of innovative energy efficiency measures in the buildings sector. These services provide valuable support and expertise to building owners and operators, facilitating the identification and implementation of energy-saving opportunities.

In conclusion, Law No. 139 of 19.07.2018 on energy efficiency is a pivotal piece of legislation that establishes the primary framework for promoting energy efficiency in the Republic of Moldova, with a particular focus on the buildings sector. Through the incorporation of key elements from the EE Directive, this law sets forth the principles and requirements necessary for driving energy efficiency measures, such as the development of an Energy Efficiency Strategy, mandatory annual renovations, EE obligation schemes, integration of energy efficiency in public procurement, and the promotion of energy services. By adhering to these provisions, Moldova can effectively advance its energy efficiency goals and ensure a sustainable and energy-efficient future for its buildings sector.

Law No. 128 of 11.07.2014 on energy performance of buildings: Recognizing the buildings sector as a key contributor to energy consumption, the Republic of Moldova has prioritized the adoption of legislative measures to address energy performance in buildings. The European Union's Energy Performance of Buildings Directive (EPBD) serves as a guiding framework at the European level, providing essential principles for energy efficiency in the built environment. In alignment with these objectives, Law No. 128 of 11.07.2014 incorporates all pertinent elements of the EPBD into Moldovan legislation, ensuring a comprehensive approach to energy performance in buildings.

By transposing the EPBD into domestic legislation, Law No. 128 of 11.07.2014 establishes a robust framework for improving the energy efficiency of buildings in the Republic of Moldova. The law encompasses various aspects outlined in the EPBD, including the general methodology for calculating energy performance, the application of minimum energy performance requirements for different categories of buildings, and the consideration of energy efficiency measures during major renovations. This comprehensive approach ensures that both new constructions and existing buildings undergoing significant renovations adhere to specific energy performance standards, contributing to a more sustainable built environment.

Law No. 128/2014 also emphasizes the importance of energy performance certification, a crucial aspect of promoting energy efficiency in buildings. This certification process involves the evaluation of a building's energy performance and the issuance of a certificate that provides information on its energy efficiency rating. By mandating energy performance certification, the law encourages building owners to assess and improve the energy efficiency of their properties, ultimately leading to reduced energy consumption and environmental impact.

Furthermore, Law No. 128/2014 highlights the significance of regular inspections of heating and air conditioning systems in buildings. These inspections ensure that these systems are functioning optimally and comply with energy efficiency standards. By promoting the maintenance and monitoring of these systems, the law aims to enhance energy efficiency and mitigate energy losses associated with inefficient heating and cooling practices.

Another notable provision of Law No. 128/2014 is the inclusion of a national plan for increasing the number of nearly zero energy buildings (NZEBs). NZEBs are characterized by their minimal energy consumption, primarily relying on renewable energy sources and high energy performance standards. The integration of a national plan underscores the Republic of Moldova's commitment to transitioning towards a more sustainable built environment by promoting the construction and renovation of NZEBs.

In conclusion, Law No. 128 of 11.07.2014 on energy performance of buildings reflects the Republic of Moldova's dedication to improving energy efficiency in the buildings sector. By aligning with the EPBD and transposing its provisions into domestic legislation, the law establishes a comprehensive framework for enhancing energy performance in buildings. Through the application of minimum energy performance requirements, energy performance certification, regular inspections of heating and air conditioning systems, and the promotion of nearly zero energy buildings, the Republic of Moldova is paving the way for a more sustainable and energy-efficient built environment.

Law No. 10 of 26.02.2016 on the promotion of the use of energy from renewable sources sets forth mandatory national objectives to increase the share of energy derived from renewable sources. These objectives provide a clear roadmap for the Republic of Moldova to transition towards a more sustainable energy landscape. By establishing specific targets, the law creates a framework for achieving significant renewable energy penetration in the building sector, thereby contributing to reduced greenhouse gas emissions and enhanced energy security.

In addition to the national objectives, Law No. 10 addresses various support schemes and mechanisms to incentivize the adoption of renewable energy in buildings. These schemes facilitate financial assistance, grants, and other incentives to promote the installation of renewable energy systems, such as solar panels, biomass boilers, and geothermal heat pumps. By providing financial support, the law encourages building owners to invest in renewable energy technologies and contribute to the overall renewable energy capacity of the country.

Furthermore, the law establishes provisions related to guarantees of origin, which ensure transparency and traceability of renewable energy generation. These guarantees play a crucial role in verifying the origin and environmental attributes of energy produced from renewable sources. By implementing a robust guarantee of origin system, the Republic of Moldova ensures the credibility and reliability of renewable energy claims, promoting trust and confidence in the renewable energy sector.

Law No. 10 also addresses administrative procedures and the facilitation of renewable energy producers' access to networks. These provisions aim to streamline the administrative processes involved in connecting renewable energy systems to the grid. By simplifying and expediting these procedures, the law promotes the integration of renewable energy into the existing energy infrastructure, facilitating the uptake of renewable energy technologies in the buildings sector.

Within the buildings sector, Law No. 10 encourages and promotes the use of renewable energy sources for heating, cooling, and electricity production through net metering schemes. Net metering allows building owners to generate renewable energy on-site and feed the excess electricity back into the grid, receiving credits or compensation for the energy they contribute. By incentivizing net metering, the law empowers building owners to become active participants in the renewable energy transition, fostering a decentralized and sustainable energy system.

Additionally, the law designates the Energy Efficiency Agency as the primary implementing body for the state policy on renewable energy sources. This designation ensures effective coordination, implementation, and monitoring of the various measures and initiatives related to renewable energy in the buildings sector. The Energy Efficiency Agency plays a crucial role in disseminating information, providing technical support, and facilitating the transition to renewable energy in the Republic of Moldova.

In conclusion, Law No. 10 of 26.02.2016 on the promotion of the use of energy from renewable sources provides a robust legal framework to foster the adoption of renewable energy in the buildings sector. Through its mandatory national objectives, support schemes, guarantees of origin, administrative procedures, and promotion of net metering, the law facilitates the integration of renewable energy technologies, contributing to improved energy performance and the development of nearly zero energy buildings. By designating the Energy Efficiency Agency as the main implementing body, the law ensures effective coordination and implementation of the state policy on renewable energy sources in the Republic of Moldova.

Secondary legislation

The subsequent paragraphs provide an overview of the secondary legislation and regulations that have been enacted to address energy efficiency (EE) in buildings, in accordance with the Energy Performance of Buildings Directive (EPBD) and Energy Efficiency (EE) Laws.

Energy performance of buildings

To facilitate the implementation of *Law No. 128 of 11.07.2014 on the energy performance of buildings*, the Republic of Moldova has developed a comprehensive set of secondary legislative acts and regulations. These measures aim to improve the energy efficiency of buildings, promote sustainable practices, and establish a robust framework for energy certification. Here are the enhanced details:

Government Decision No. 896 of 21.07.2016: This decision plays a crucial role in the energy certification process by approving the Regulation on the certification procedure for the energy performance of buildings and building units. It outlines the requirements and procedures for certifying the energy performance of buildings, including the necessary documentation, calculation methodology, and issuance of energy performance certificates. This regulation provides clear guidelines for energy auditors and certifiers to follow during the certification process.

Government Decision No. 1325 of 12.12.2016: With the approval of the Regulation on the regular inspection of heating systems in buildings, this decision ensures that heating systems comply with energy performance standards and operate efficiently. The regulation sets guidelines for conducting regular inspections of heating systems, including boilers, radiators, and distribution networks, to verify their proper functioning, identify potential energy losses, and recommend improvements to enhance energy efficiency.

Government Decision No. 1103 of 14.11.2018: Focusing on air conditioning systems, this decision approves the Regulation on the regular inspection of air conditioning systems in buildings. It establishes guidelines for the regular inspection of air conditioning systems to assess their energy efficiency, performance, and compliance with relevant standards. The regulation aims to identify opportunities for optimizing the operation of air conditioning systems, reducing energy consumption, and improving indoor comfort.

MNC M.01.01:2016: The Ministry of Regional Development and Construction approved this regulation, titled "Energy performance of buildings - Minimum requirements for energy performance of buildings." It establishes the minimum energy performance requirements for buildings, covering aspects such as thermal insulation, heating and cooling systems, ventilation, and lighting efficiency. Compliance with these requirements ensures that new buildings and major renovations meet specific energy efficiency standards.

MNC M.01.02:2016: The regulation titled "Energy performance of buildings - Methodology for the calculation of energy performance of buildings" provides a standardized methodology for calculating the energy performance of buildings. It considers factors such as building geometry, materials, thermal insulation, HVAC systems, and integration of renewable energy sources. This methodology enables energy auditors to accurately assess and compare the energy performance of different buildings.

MNC M.01.04:2016: This regulation, titled "Energy performance of buildings - Methodology for calculating the cost-optimal levels of minimum energy performance requirements for buildings and building elements," establishes a methodology to determine the cost-optimal levels of energy performance requirements. It balances energy efficiency with economic viability, aiming to identify the most cost-effective measures for achieving the desired energy performance levels in buildings and building elements.

While the energy certification scheme for buildings is still being developed, some progress has been made through the support of the EU programme - EU4Energy. The development of a draft Excel-based tool enables energy auditors and certifiers to calculate energy performance and assign energy efficiency classes (ranging from A to F) based on minimum energy performance requirements, reference building definitions, U values, climatic zones, and other factors. However, additional efforts are necessary to finalize the energy performance certificate (EPC) calculation tool, establish a National Information System for EPCs with registries, provide training and certification procedures for energy auditors and certifiers, implement a robust quality control mechanism, and effectively communicate the new EPC scheme to the public.

In conclusion, the Republic of Moldova has taken comprehensive measures to improve the energy performance of buildings and establish a framework for energy certification. The approved regulations and methodologies provide clear guidelines for energy auditors, certifiers, and building owners. With further efforts and implementation of supporting infrastructure, Moldova can successfully enhance energy efficiency, reduce greenhouse gas emissions, and create more sustainable buildings.

Secondary legislation on energy audits and energy services

In the context of energy efficiency (EE), the Republic of Moldova has implemented specific secondary legislation to support the Energy Efficiency Law (*Law No. 139 of19.07.2018*). This legislation aims to promote energy audits and energy services in the country. Here are further details:

Government Decision No. 676 of 10.09.2020: This decision plays a key role in promoting energy efficiency initiatives by approving the Regulation on Energy Auditors and Energy Audits. It sets comprehensive guidelines and requirements for the performance of energy audits, including for buildings. The Regulation describes the requirements for qualification and registration (update, de-registration) of energy auditors in the national electronic register, as well as the procedure for mutual recognition of energy auditor acts/certificates issued by accredited bodies and/or competent authorities/institutions of EU Member

States, Contracting Parties to the Energy Community Treaty and countries with which the Republic of Moldova has bilateral agreements.

The Regulation describes the conditions for carrying out energy audits, the requirements for reporting, quality assurance and verification of energy audits, as well as the training of energy auditors working in the Republic of Moldova.

According to this regulation, energy audits shall be carried out in accordance with the following standards SM EN 16247-1 - Energy audit. Part 1: General requirements - applicable to all categories; SM EN 16247-2 - Energy audits. Part 2: Buildings - applicable to the building category; SM EN 16247-3 - Energy audits. Part 3: Processes - applicable to the industry category; SM EN 16247-4 - Energy audits. Part 4: Transport - applicable to the category Transport.

It therefore serves as a fundamental framework for ensuring accurate and effective energy audits across different sectors.

Government Decision No. 1093 of 31.12.2013: This decision approves the Regulation on the provision of energy services, which sets the framework for energy service providers to offer energy efficiency solutions to consumers. The regulation outlines the rights and obligations of both service providers and consumers, contractual arrangements, quality assurance mechanisms, dispute resolution procedures, and financial mechanisms. It aims to promote the development of energy service companies, encourage the uptake of energy efficiency measures, and facilitate the implementation of energy performance contracts.

Currently, a register of energy auditors is developed, comprising auditors specialised by sector: buildings - 63 people, industry - 23 and transport - 21 auditors. Minimum requirements for energy audit by each sector are developed, Guidelines for the preparation of energy audit in buildings are developed, and Minimum requirements to be taken into account when preparing energy audits in the public lighting sector are approved, according to the model energy audit report.

However, it is important to note that secondary legislation necessary for implementing the updated Energy Efficiency Law (Law No. 139 of 19.07.2018) needs to be adjusted. This indicates the need for further development and implementation of the regulatory framework to fully support the objectives of the updated law.

Strategic documents and plans

The primary aim of the national energy savings policy in the Republic of Moldova is to actively promote and facilitate the efficient utilization of energy resources. The overarching goal is to ensure the long-term availability of energy at affordable rates while effectively addressing the environmental impacts and risks associated with energy consumption. To achieve this, the energy savings policy framework is guided by a set of official policy documents that outline clear objectives and comprehensive strategies for improving energy performance across the country.

These policy documents provide a roadmap for Moldova's energy sector, encompassing various aspects such as energy efficiency, renewable energy utilization, and sustainable development. They serve as a foundation for implementing targeted measures and initiatives to optimize energy consumption patterns and reduce the overall energy intensity of the nation.

Energy Strategy of the Republic of Moldova

One of the key policy documents is the "**Energy Strategy of the Republic of Moldova until 2030**." This strategy, initially approved by the Government Decision No. 102 on 5 February 2013, is currently undergoing revision to align with evolving energy priorities. The Energy Strategy provides a vision for the development of Moldova's energy system, defining national targets for the period from 2013 to 2030 and outlining specific strategic objectives for different stages. It also outlines the measures necessary for achieving these objectives.

The Energy Strategy emphasizes three main objectives for the Republic of Moldova. Firstly, ensuring a stable energy supply for the country is a priority. This includes diversifying energy sources and enhancing energy security. Secondly, the strategy aims to facilitate the establishment of competitive markets and promote regional and European energy integration. This involves improving energy infrastructure and fostering cooperation with neighbouring countries. Lastly, the strategy focuses on promoting environmental sustainability and mitigating the impacts of climate change by reducing greenhouse gas emissions and enhancing energy efficiency.

Within the Energy Strategy, the importance of adopting energy-efficient technologies and implementing thermal insulation measures in building envelopes is highlighted. These measures are seen as crucial steps to reduce energy consumption in the buildings sector while simultaneously improving the comfort and well-being of occupants. By enhancing the energy efficiency of buildings, the strategy aims to achieve significant energy savings and contribute to the overall energy performance objectives.

In conclusion, the Energy Strategy of the Republic of Moldova until 2030 serves as a crucial policy document that sets the direction for energy performance objectives and strategies in the country. The strategy emphasizes the importance of energy efficiency measures, including thermal insulation and adoption of energy-efficient technologies, in the buildings sector. It also highlights the significance of promoting renewable energy sources, reducing energy consumption, and renovating public buildings. By aligning with the goals outlined in the Energy Strategy and implementing effective policies and measures, Moldova can enhance its energy performance, contribute to environmental sustainability, and achieve a more resilient and efficient energy system.

According to Decision No 2021/14/MC-EnC of the Ministerial Council of the Energy Community, the Republic of Moldova shall transpose into its national legislation Regulation (EU) 2018/1999 on Energy Union Governance and Climate Action (part of the Clean Energy Package), one of the requirements of which is the elaboration and approval of National Integrated Energy and Climate Plans. Therefore, as a Contracting Party to the Energy Community Treaty, in order to meet the requirements of international commitments, the Republic of Moldova shall develop a new public policy document defining the actions and measures envisaged for the energy sector for the period up to 2030 (which corresponds to the current Energy Strategy).

The Government of the Republic of Moldova has initiated the process of developing a new **Energy Strategy of the Republic of Moldova until 2050**, taking into account the results of the implementation of the Energy Strategy 2030 and critically assessing the ability and opportunity to achieve the proposed goals for the energy sector, developing a clear vision and a path with defined and measurable objectives for the benefit of the participants in the electricity and gas markets, energy consumers and the national economy in general.

The main objective of the development of the new energy strategy is to encourage the main stakeholders in the energy sector to develop a common understanding of the activities and measures required for the sustainable development of the sector. In addition, it aims to create the necessary conditions to increase the confidence of potential international and private investors to increase their investments in the national energy sector, thus supporting the sustainable development of the country.

The objectives and actions set out in the new Energy Strategy will be SMART (Specific, Measurable, Achievable, Relevant and Time-bound), with progress objectively measured by means of time-bound qualitative and quantitative indicators (annual targets, intermediate milestones, etc.), which will include early warning mechanisms and allow monitoring of the implementation of each objective and action.

The Energy Strategy 2050 will provide the necessary framework to ensure the sustainable development of the sector, addressing several dimensions of the development process and recognising their interdependence. It is proposed that the new energy strategy will focus on five strategic objectives, which will be developed within the new energy strategy as follows:

- Enhancing energy security
- Developing competitive energy markets and regional integration
- Promoting energy efficiency
- Development of sustainable renewable energy sources
- Consumer protection

The multisectoral approach is expected to enable Moldova to address a number of challenges. The implementation of the proposed interventions will improve the efficiency and quality of transmission and distribution services, promote energy efficiency throughout the supply chain (from production to final consumers) and support the sustainable development of the energy sector.

National Energy Efficiency Action Plans

Law 139/2018, updated in 2023, provides for the development of an integrated national energy and climate plan. The plan is to be developed and structured in accordance with the recommendations of the Energy Community Secretariat and the relevant European Union legislation in this field. The plan will define and describe the state policy objectives, including in the field of energy efficiency, and energy efficiency policy measures for all sectors of the national economy, including the scheme of energy efficiency obligations to be implemented. The Integrated National Energy and Climate Plan will describe the amount of energy savings to be achieved over a given period of time and the measures to be taken to achieve them, including sources and financing mechanisms.

The calculation of energy savings shall take into account the lifetime of the measures and the rate at which the savings diminish over time. In the integrated energy and climate plans, the government will describe in detail the methods and provisions used to ensure compliance with the mandatory calculation requirement.

Local government authorities must draw up and approve integrated local energy and climate plans. These plans are to be updated every two years.

In order to motivate small and medium-sized enterprises to carry out an energy audit and implement related energy efficiency measures, Law 139/2018 provides for the possibility of including support schemes to compensate for related expenses in the Integrated National Energy and Climate Plan.

Overall, the Integrated National Energy and Climate Plan will provide a comprehensive framework for promoting energy efficiency in Moldova. Through a combination of incentives, guidelines and awareness-raising activities, the plan will accelerate the implementation of EE measures and technologies, diversify the energy mix and contribute to a more sustainable and resilient energy sector.

In 2021, the National Action Plan for Mitigating the Energy Crisis was developed and approved by GD No. 433/2021. According to it, the implementation of the project "Energy Efficiency in the Republic of Moldova" started in 2022, which aims to improve the energy efficiency of public buildings throughout the country, resulting in significant environmental benefits through energy savings and reduction of carbon emissions, and leading to estimated savings of 16.8 GWh/year in electricity and 55.3 GWh/year in heat, which is equivalent to monetary savings of 5.2€ million per year.

Chapter II. Reducing energy consumption in public buildings

Reducing energy consumption in public buildings

The buildings sector plays a critical role in the energy consumption landscape of the Republic of Moldova, being the largest consumer of energy resources. It is imperative to prioritize energy efficiency measures in this sector to effectively reduce overall energy consumption in the country. Figure 2.1 illustrates the significant contribution of the buildings sector, accounting for 58 per cent of the total final energy consumption in 2021.

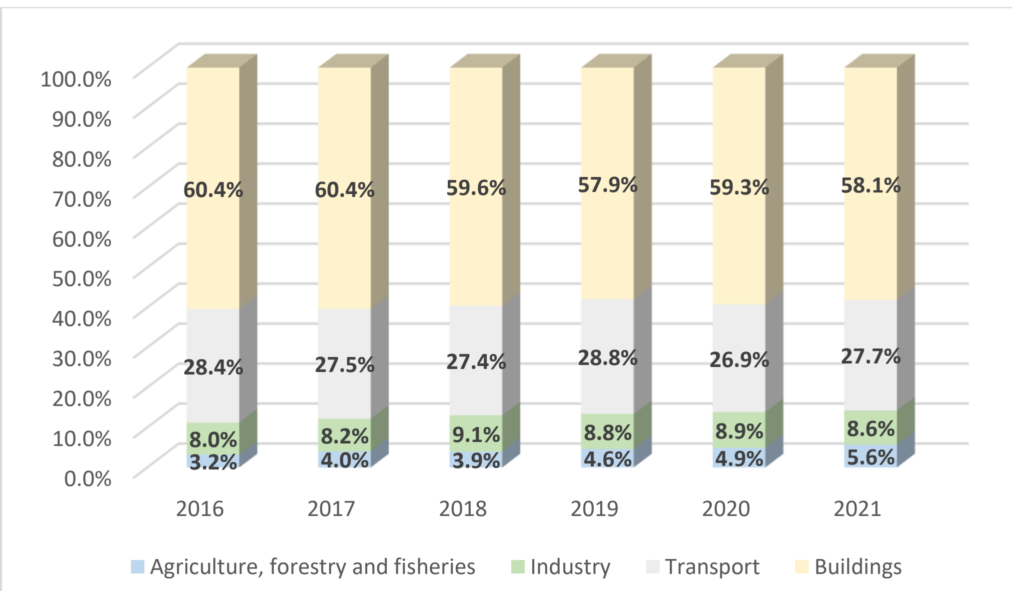


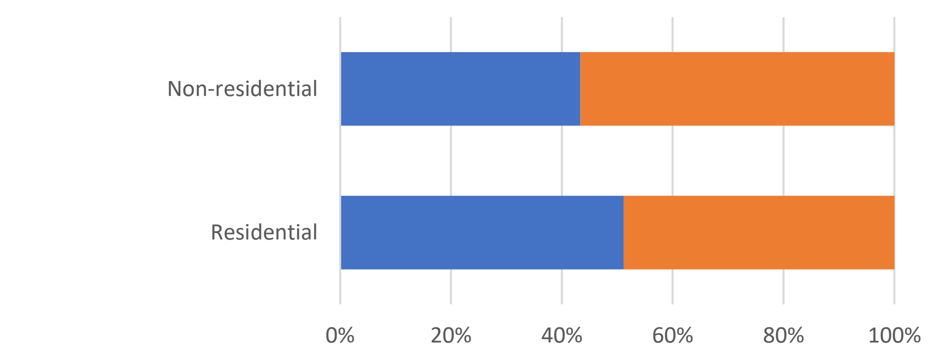
Figure 1. Final energy consumption by sector in Republic of Moldova[1]

Further analysis of the buildings sector reveals that residential buildings constitute a substantial 87 per cent of the national building stock, with non-residential buildings accounting for the remaining 13 per cent. In terms of energy consumption, residential buildings consume 82.5 per cent of the total final energy

[1] National Bureau of Statistics of the Republic of Moldova. Energy balance of the Republic of Moldova. 2022. https://statistica.gov.md/files/files/publicatii_electronice/balanta_energetica/Balanta_energetica_editia_2022_rom.pdf

in the sector, while non-residential buildings contribute 17.5 per cent. This breakdown highlights the significance of addressing energy efficiency in residential buildings, given their predominant share in the energy consumption landscape. Various non-residential buildings, including offices, educational facilities, hospitals, hotels, restaurants, sports facilities, wholesale and retail establishments, and mixed-use buildings, as defined by the Energy Performance of Buildings Law (EPB Law)[2], also require attention to optimize their energy usage.

To gain a deeper understanding of the buildings sector, it is beneficial to analyse the distribution of the total heated area among different sub-categories of buildings. This information provides valuable insights into the areas where energy efficiency measures can have the most significant impact.



	Residential	Non-residential
Share of area by buildings sector	87%	13%
Share of energy consumption by buildings sector	83%	17%

Figure 2. Shares of energy consumption and area of buildings subsectors in Republic of Moldova

Table 1. Total heated area by buildings subcategories in Republic of Moldova [EU4Energy Governance, 2020, pg. 14]

Buildings Categories	Total heated area by category [m²]	Specific energy consumption [kWh/m²]
Single Family Houses	65,082,949	290
Apartment Buildings	22,182,282	260
Office Buildings	1,791,731	170
Educational Buildings	2,585,980	199
Hospitals	704,626	326
Hotels	816,326	235
Restaurants	3,319,777	185
Sports Buildings	91,543	178
Wholesale and Retail Buildings	3,884,579	199
Mixed use Buildings	241,033	254

[2] Law No 128 of 11.07.2014 on energy performance of buildings. Available at: https://www.legis.md/cautare/getResults?doc_id=95262&lang=ro

Total	**100,700,826**	**-**

The following Table shows the total energy consumption by sector in Republic of Moldova in 2021.

Table 2. Final energy consumption by sector, 2021.

Sector	Final energy consumption [ktoe[3]]	Final energy consumption [TJ]
Industry	245	10,619
Transport	789	32,979
Residential sector	1,368	57,075
Trade and public services	290	12,223

Considering the substantial contribution of the buildings sector to the overall energy consumption, it is evident that prioritizing energy efficiency measures in this sector is of utmost importance. Furthermore, special attention should be given to public buildings, which often accommodate a significant number of users, such as schools. As per EU legislation, public buildings are expected to set an example by adopting best practices in energy efficiency. Therefore, public buildings should be a focal point in the decision-making and planning processes aimed at enhancing energy efficiency in the country. By addressing energy efficiency in public buildings, not only can significant energy savings be achieved, but they can also serve as role models for other sectors and inspire broader adoption of sustainable practices.

Recommended measures to reduce energy consumption in public buildings

The methodology used in this study to determine the proposed measures consists of two steps. Firstly, priority measures were identified based on meetings and interviews with representatives of government bodies. These discussions helped determine the measures that are currently prioritized by the government. Secondly, a literature review was conducted to consider measures outlined in strategic documents related to energy efficiency, such as national energy efficiency plans, the strategic approach of the Energy Efficiency Fund, and national legislation.

In addition, the availability of solutions in the local market played a key role in selecting the measures. To assess this, databases of efficient products, such as the EBRD Green Economy Financing Facility database, were reviewed. [EBRD, n.d.] The identified measures have been categorized and sub-categorized, as presented in Table 3.

Table 3. Determined priority measures for the public buildings sector in Republic of Moldova

Measure	Category

[3] thousands of tonnes oil equivalent

Energy audits	Legislative measure
Thermal insulation work on exterior walls	Technological measures and building materials
Thermal insulation work on the roof	
Basement thermal insulation works	
Replacement of windows and external doors: **Windows** **Doors**	
Energy efficiency works in indoor lighting	
Energy efficiency works in outdoor lighting: **LED luminaires** **Counters/monitoring systems**	
Measures for utilization of renewable energy sources **Photovoltaic systems** **Solar thermal collectors** **Hybrid PV thermal solar panels** **Solid biomass thermal power plants** **Air-to-water heat pumps** **Ground-source heat pumps**	Systems and equipment
Heating system measures **Thermal points** **Condensing central heating systems (including room thermostat)** **Thermal insulation of heat supply pipes** **Replacement of radiators (including thermostat valves)**	
Measures for ventilation and air conditioning	

As depicted in the table, the identified measures are divided into three distinct groups, each playing a crucial role in promoting energy efficiency in public buildings:

Legislative measures

This category emphasizes the importance of improving the legislative framework to streamline the implementation of energy efficiency measures. By regulating the structure and content of energy audits, policymakers can ensure that consumers have access to comprehensive data for informed decision-making. Establishing minimum quality thresholds and actively promoting the benefits of energy consumption reduction further strengthens this category. These measures create an enabling environment for energy efficiency initiatives and encourage widespread adoption.

Technological measures and building materials

This group focuses on enhancing building characteristics and efficiency through technological advancements and optimized use of building materials. Measures directed at the building envelope, such as thermal insulation work on exterior walls, roofs, and basements, help minimize energy losses and create a more thermally efficient building envelope. Upgrading windows and external doors, improving indoor and outdoor lighting systems, and utilizing energy-efficient products contribute to reducing energy demand and enhancing overall energy performance. By incorporating these measures, public buildings can significantly decrease their energy consumption and environmental footprint.

Systems and equipment

This category targets energy and non-energy systems within public buildings. Measures to improve heating, ventilation, and air conditioning (HVAC) systems are essential for optimizing energy usage and maintaining comfortable indoor environments. Additionally, the utilization of renewable energy sources, such as photovoltaic systems - especially in combination with heat pumps, vacuum tube solar collectors, and solid biomass thermal power plants, helps diversify energy sources and reduce reliance on fossil fuels. While these measures may not directly reduce building energy consumption, they contribute to the broader goal of achieving energy security, promoting sustainability, and mitigating environmental impacts.

The following subchapters provide a comprehensive overview of these measures, offering detailed insights into their implementation, potential benefits, and specific considerations for different types of reference buildings. By tailoring the recommendations to suit the diverse needs of public buildings, stakeholders can effectively prioritize and implement the most suitable energy efficiency measures. Through a combination of legislative improvements, technological advancements, and optimized systems and equipment, the Republic of Moldova can make significant strides in reducing energy consumption, enhancing sustainability, and creating more energy-efficient public buildings.

Legislative measures

The legislative measures should focus on the local and national planning about the energy efficiency of the public buildings which is in accordance with the national legislation and furthermore, the public buildings need to set up an example for the general public. For example, the Law 139/2018 states that in order to promote the exemplary role of public buildings, this Law establishes as objective the annual renovation of a certain area of buildings in the public domain of the state, heated and/or cooled, in which specialized central public administration authorities operate, so that at least the minimum energy performance requirements set out in art. 9 of Law nr. Regulation (EU) No 128/2014 on the energy performance of buildings. Because public buildings are spaces of gathering and engagement, where community members interact with local services and government functions. Through their energy-efficient initiatives, these buildings can educate the public about the tangible benefits of sustainability, encouraging citizens to adopt similar practices in their own homes and workplaces. Public buildings also have the potential to influence market trends. As early adopters of energy-efficient technologies, they create demand for these solutions, spurring innovation and driving down costs over time. This market influence can catalyze a broader societal transition towards sustainable energy practices.

Additionally, the local public administration authorities shall contribute to achieving national objectives in the field of energy efficiency and promote energy efficiency locally, exercising the following attributions:

a) develops and approves local action plans in the field of energy efficiency, targeting second-level local public administration authorities, as separate documents or as an integral part of general development plans, ensures their execution and monitors their implementation.

b) initiates and finances projects in the field of energy efficiency and contributes to their co-financing, within the limits of local budgets.

c) organizes public procurement procedures for energy services and concludes contracts in this regard.

d) contribute, at the local level, to the implementation of state policy in the field of energy efficiency.

e) participate, at local level, in the dissemination of information on energy efficiency, including financing mechanisms and instruments in the field of energy efficiency, the regulatory framework adopted in order to achieve national objectives.

f) contribute, at the local level, to the organization of seminars, conferences, and exhibitions to promote energy efficiency.

In recent years, Local Energy Efficiency Action Plans (LEAPs) have emerged as instrumental tools for communities and municipalities striving to enhance energy efficiency and promote sustainable development. These plans offer a plethora of benefits while being driven by diverse motivations that underscore their significance in the context of modern urban planning and environmental stewardship.

Benefits of Creating Local Energy Efficiency Action Plans

Tailored Solutions for Local Context. LEAPs empower communities to fashion energy efficiency strategies tailored to their unique contexts, encompassing factors such as local resources, climate conditions, and building characteristics. This customization ensures that the implemented measures are both effective and relevant.

Economic Gains and Job Creation. An undeniable advantage of LEAPs is their potential to stimulate economic growth and generate employment opportunities. The energy efficiency projects, integral to LEAPs, often involve local businesses and service providers, driving economic activity within the community.

Energy Cost Reduction. By improving energy efficiency, LEAPs substantially lower energy consumption, leading to decreased utility bills for both the municipal entities and residents. This financial relief contributes to the overall economic wellbeing of the community.

Quality of Life. The reduced energy consumption facilitated by LEAPs triggers diminished environmental impact, thus enhancing air quality and fostering a healthier environment for residents.

Long-Term Cost Savings. Initial investments in energy efficiency measures, undertaken as part of LEAPs, produce significant long-term energy cost savings. These financial gains can be redirected toward addressing other pressing community needs.

Awareness and Education. The process of formulating LEAPs serves as an educational platform, raising awareness about energy conservation and fostering behavioral changes that support a culture of sustainability.

Motivations for Creating Local Energy Efficiency Action Plans

Legal and Regulatory Imperatives. The legal and regulatory regulations compel municipalities to establish and implement energy efficiency plans, often tied to specific energy reduction targets. Compliance with these regulations underscores the proactive stance of communities in contributing to global sustainability goals.

Access to Funding Opportunities. LEAPs are poised to benefit from a range of funding sources, both governmental and private, which prioritize initiatives aligned with energy efficiency and sustainable practices.

Economic Incentives. Communities embracing energy efficiency through LEAPs often have economic incentives such as tax breaks, grants, and subsidies. These incentives add a layer of financial viability to efficiency projects.

Strengthened Energy Security. LEAPs contribute to enhanced energy security by minimizing reliance on external energy sources. Communities become less susceptible to energy supply disruptions and price volatility.

Smart Urban Planning. LEAPs intricately align with principles of smart urban planning by advocating for efficient land use, resilient infrastructure, and cohesive community development.

Climate Adaptation and mitigation. Energy efficiency measures within LEAPs aid communities in adapting to changing climate conditions. Reduced energy demand during extreme weather events contributes to community resilience.

In conclusion, Local Energy Efficiency Action Plans offer communities a roadmap toward enhanced energy efficiency, sustainable growth, and an improved living environment. The multiplicity of benefits they confer, combined with the motivations driving their adoption, underscores their critical role in advancing environmental stewardship and resilient urban planning. LEAPs stand as testaments to the commitment of communities to global sustainability and their dedication to shaping a greener, more sustainable future.

Technological measures and building materials recommended to reduce energy consumption in public buildings

Thermal insulation work on exterior walls

Thermal insulation is an essential measure to improve energy efficiency in public buildings. External walls are one of the main sources of heat loss in buildings, and by adding insulation to the walls, the building can retain heat more effectively and reduce the need for heating.

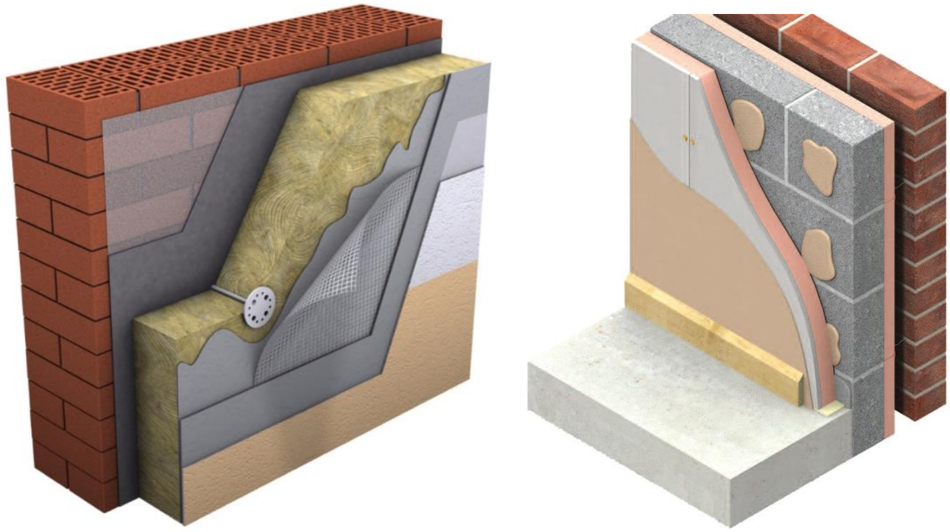


Figure 3. Thermal insulation on external walls with a) mineral wool and b) expanded polystyrene[4]

The installation process begins with the selection of the right insulation material. Different materials are available, including **mineral wool and expanded polystyrene**. The choice of material depends on factors such as cost, thermal performance, and fire safety.

The insulation is then installed on the **exterior of the building**, typically in the form of panels or sheets. It is fixed to the wall using mechanical fasteners, adhesives, or both. After installation, the insulation is covered with a finishing layer, which can be made of various materials such as render, cladding, or paint. The finishing layer not only provides an aesthetic appearance but also serves as protection for the insulation against weather and UV damage.

The insulation can be installed on the **interior of the building** as well, especially when the building is cultural heritage, or the space does not allow it to be installed on the exterior of the building. There are several considerations to be noted when installing the insulation on the interior side. For example, the wall itself can act as an accumulator of heat, which is not the case with utilization of thermal insulation on the interior wall.

In addition to reducing energy consumption and emissions, installing thermal insulation on external walls can also improve the thermal comfort of building occupants and reduce noise pollution. It can also increase the value of the building and reduce maintenance costs by protecting the walls from weather damage.

Overall, installing thermal insulation on external walls is an effective energy efficiency measure that can provide significant benefits for public buildings. It is important to select the right insulation material and ensure proper installation to achieve maximum energy savings and avoid any potential problems such as moisture build-up or fire hazards.

[4] Available at: https://th.bing.com/th/id/OIP.HkTNaCqRAyy521neYwJLxAHaF7?pid=ImgDet&rs=1
https://static.cmostores.com/uploads/products/4/l/32905_4.jpg

Thermal insulation of roof

Thermal insulation of roofs is an important measure to improve energy efficiency in public buildings. Roofs are one of the major sources of heat loss in buildings, and by adding insulation to the roof, the building can retain heat more effectively and reduce the need for heating.

Figure 4. Thermal insulation of roof a) Suspended ceiling b) layover[5]

The installation process involves the selection of the right insulation material. Different materials are available, including **mineral wool, expanded polystyrene, and polyurethane foam**. The choice of material depends on factors such as cost, thermal performance, and fire safety.

The insulation is then installed on **the inside or outside of the roof**, depending on the type of roof and insulation material used. The insulation can be installed in the form of rolls, boards, or sprayed foam. After installation, the insulation is covered with a finishing layer, which can be made of various materials such as drywall or ceiling tiles.

In addition to reducing energy consumption and emissions, thermal insulation of roofs can also improve the thermal comfort of building occupants and reduce noise pollution. It can also prevent roof damage caused by moisture and reduce the risk of ice dam formation.

Overall, thermal insulation of roofs is an effective energy efficiency measure that can provide significant benefits for public buildings. It is important to select the right insulation material and ensure proper installation to achieve maximum energy savings and avoid any potential problems such as moisture buildup or fire hazards.

Basement thermal insulation works

The consideration of these measures is similar to the measure for installation of thermal insulation of external walls, with some restrictions.

The installation process involves the selection of the right insulation material. Different materials are available, including **rigid foam boards and spray foam**. The choice of material depends on factors such as

[5] Available at: https://5.imimg.com/data5/SELLER/Default/2020/9/WW/SU/MT/110998344/false-ceiling-acoustic-insulation-500x500.jpg
https://www.insulationshop.co/image/catalog/blog/technical_guidance_on_pitched_roof_insulation_2.jpg

cost, thermal performance, and moisture resistance which is key element in the case of basement thermal insulation installation.

Figure 5.Thermal insulation of basement on the interior side[6]

Additionally, the external side of the basement is usually not approachable, or it is hard to approach, thus the **interior side** of the wall is more common choice.

Additionally, if the basement is not heated, due to its use (for example it is used for storage without the need for heating), **installation of thermal insulation on the ceiling** of the basement can be considered.

In addition to reducing energy consumption and emissions, basement insulation can also improve the thermal comfort of building occupants and reduce noise pollution. It can also prevent moisture and mold buildup, which can lead to health issues and structural damage.

Overall, basement insulation is an effective energy efficiency measure that can provide significant benefits for public buildings. It is important to select the right insulation material and ensure proper installation to achieve maximum energy savings and avoid any potential problems such as moisture buildup or fire hazards.

Replacement of windows and external doors

Replacement of old windows and doors is an important measure to improve energy efficiency in public buildings. Windows and doors are often a major source of heat loss in buildings, and by their improvement, the building can retain heat more effectively and reduce the need for heating.

[6] Available at: https://celluloseman.ca/wp/wp-content/uploads/2020/08/basement-insulation-1536x864.jpg

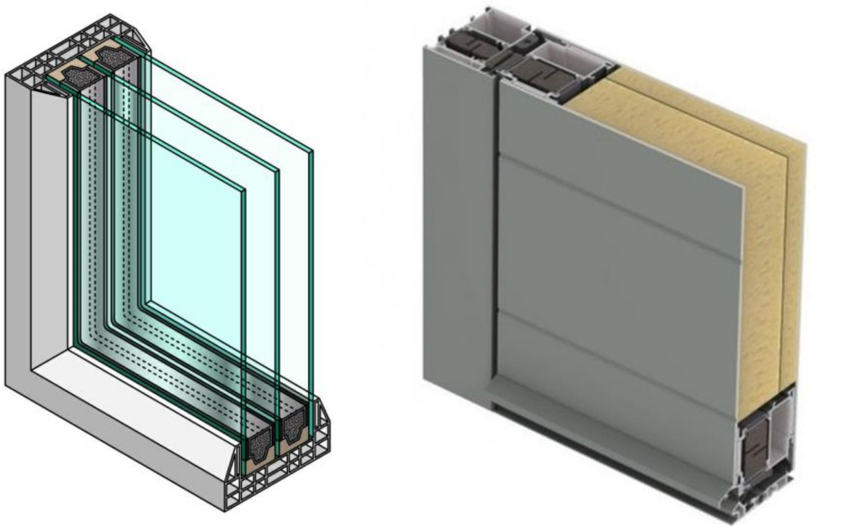


Figure 6. Energy efficient windows and doors. a) triple glazed window b) insulation in doors[7]

The installation process involves the selection of the right windows and doors. Different materials are available, including **double-glazed or triple-glazed** glass, low-emissivity (Low-E) coatings, and insulated frames. The choice of material depends on factors such as cost, thermal performance, and noise reduction.

For windows, double-glazed or triple-glazed glass can be installed, which features two or three panes of glass with an **air or gas-filled** space in between that provides insulation. Low-E coatings can be added to the glass to reduce the amount of heat that passes through the glass while allowing natural light to enter. Insulated frames can also be installed to reduce heat transfer through the frame.

For doors**, insulation can be added to the door itself or the frame**. The door can be made of materials such as **fiberglass, insulated steel, or wood with a foam core**. The frame can be made of materials such as vinyl, fiberglass, or wood, with insulation added to reduce heat transfer.

In addition to reducing energy consumption and emissions, thermal insulation for windows and doors can also improve the thermal comfort of building occupants and reduce noise pollution. It can also increase the security of the building and reduce the risk of moisture or mold build-up.

Overall, thermal insulation for windows and doors is an effective energy efficiency measure that can provide significant benefits for public buildings. It is important to select the right insulation material and ensure proper installation to achieve maximum energy savings and avoid any potential problems such as condensation or air leaks.

Energy efficiency works in indoor lighting

Replacing indoor lights with LED is another effective measure to improve energy efficiency in public buildings. LED lights are much more efficient than traditional incandescent or fluorescent bulbs, using up to 80 per cent less energy to produce the same amount of light.

[7] Available at: https://modernize.com/wp-content/uploads/2015/10/triple-pane-windows.jpg
https://neufert-cdn.archdaily.net/uploads/photo/image/111631/large_Webp.net-resizeimage__34_.jpg

Figure 7. Range of lightning bulbs for indoor use[8]

The installation process involves selecting the right **LED bulbs** for the application. There are a variety of LED bulbs available on the market, including bulbs that can be used in **existing light fixtures** or **integrated LED fixtures**. The choice of bulb depends on factors such as color temperature, brightness, energy label and energy efficiency class, and compatibility with the existing electrical system.

Replacing indoor lights with LED can provide significant energy savings and reduce the need for frequent bulb replacements. LED bulbs also have a longer lifespan than traditional bulbs, which reduces maintenance costs and waste. In addition, LED bulbs emit less heat, which can reduce the load on the building's cooling system during hot weather.

Overall, replacing indoor lights with LED is a simple and effective way to improve energy efficiency in public buildings. It is important to select the right LED bulb for the application and ensure proper installation to achieve maximum energy savings and avoid any potential problems such as flickering or compatibility issues with the existing electrical system. The energy label and energy efficiency class should be considered when implementing this measure.

Energy efficiency works in outdoor lighting

Improving the outdoor lighting system in public buildings can also contribute to energy efficiency, especially when coupled with counters and monitoring systems. Outdoor lighting is often used for safety, security, and aesthetic purposes, but it can also consume a significant amount of energy.

[8] Available at:
https://cdn.shopify.com/s/files/1/0247/4082/3118/articles/Untitled_design_10_480x.jpg?v=1604070595

Figure 8. Outdoor LED[9]

To improve energy efficiency, outdoor lighting fixtures can be replaced with **LED lights**, which are much more efficient than traditional lighting sources. LED lights also have a longer lifespan, reducing maintenance costs and waste. In addition, **motion sensors or timers** can be installed to ensure that the lights are only on when needed, further reducing energy consumption. The energy label and energy efficiency class of the light should be considered when implementing this measure.

Counters and monitoring systems can also be installed to measure and control energy usage of outdoor lighting. For example, smart lighting systems can automatically adjust lighting levels based on the time of day, weather conditions, or occupancy. This ensures that outdoor lighting is only on when needed and reduces the risk of over-lighting, which can waste energy and cause light pollution.

Overall, improving the outdoor lighting system in public buildings can provide significant energy savings and reduce the environmental impact of the building. By coupling LED lights with motion sensors, timers, and monitoring systems, building owners can maximize energy efficiency and reduce energy costs. It is important to select the right lighting fixtures and control systems and ensure proper installation to achieve maximum energy savings and avoid any potential problems such as over-lighting or malfunctioning sensors.

Systems, equipment, installations to reduce energy consumption in public buildings

Renewable energy sources valorisation works

For the consideration of the possibilities to utilize the available onsite renewable energy sources, three different measures are chosen.

Photovoltaic systems

The installation of photovoltaic (PV) panels is another effective way to improve energy efficiency in public buildings. PV panels use solar energy to produce electricity, which can be used to power the building's

[9] Available at: https://sc04.alicdn.com/kf/H3636203ce940450bba2dc82fceacdb45u.png

lighting, HVAC systems, and other electrical loads. By generating electricity on-site, the building can reduce its dependence on the grid and lower its energy costs.

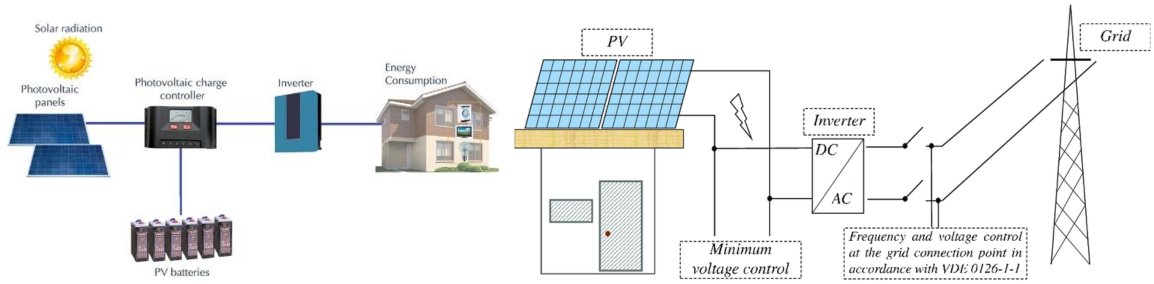


Figure 9. PV system technical scheme a) with batteries b) without batteries[10]

To install PV panels, the building owner must first assess the building's energy needs and the available roof or ground space for the panels. A qualified solar installer can help design the system and select the appropriate PV panels, inverters, and other components. The installer will also need to obtain any necessary permits and connect the system to the building's electrical system.

Two different systems are considered in this analysis, with utilization of a **battery** and with utilization of a **net metering without battery**. The batteries are one of the most expensive elements of the system from one side, and from the other, they have variable and short life span. The investment is almost doubled with its inclusion in the system. On the other side, the utilization of the net metering and a possibility to selling/netting the excessive produced energy lowers the investment and increase the affordability of the PV systems. Within the buildings sector, Law No. 10 encourages and promotes the use of renewable energy sources for heating, cooling, and electricity production through net metering schemes. Net metering allows building owners to generate renewable energy on-site and feed the excess electricity back into the grid, receiving credits or compensation for the energy they contribute. By incentivizing net metering, the law empowers building owners to become active participants in the renewable energy transition, fostering a decentralized and sustainable energy system.

The benefits of PV installations go beyond just energy savings. Solar panels produce clean, renewable energy, reducing the building's carbon footprint and promoting sustainability. In addition, PV installations can increase the building's value and provide increased return on investment over time.

It is important to note that the cost of PV installations can be significant, and the payback period may be several years. However, incentives such as tax credits, rebates, and net metering programmes can help reduce the upfront costs and accelerate the payback period.

Overall, the installation of PV panels is a valuable investment for public buildings looking to improve energy efficiency and promote sustainability. Proper planning and installation are critical to ensure maximum energy savings and increased return on investment.

[10] Available at: https://bester.energy/wp-content/uploads/2019/10/esquema-funcionamiento-instalacion-autoconsumo-aislado-en.jpg
https://www.researchgate.net/publication/340328833/figure/fig2/AS:875339144253440@1585708523327/General-connection-scheme-for-grid-connected-photovoltaic-PV-systems.png

Solar thermal collectors

Thermal solar collectors are another technology that can improve energy efficiency in public buildings. Unlike photovoltaic (PV) panels that convert solar energy into electricity, thermal solar collectors use sunlight to heat water or air, which can then be used for space heating, hot water production, or process heating.

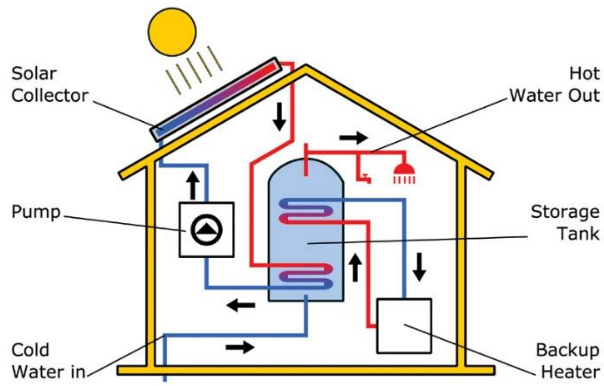


Figure 10. Solar thermal collector system scheme[11]

To install thermal solar collectors, the building owner must first **evaluate the building's energy needs** (average users, need of hot water per person for hands washing, equipment like electrical heaters for generation of hot water etc.) and available roof or ground space for the collectors. A qualified solar installer can help design the system and select the appropriate collector technology, storage tanks, and other components. The installer will also need to obtain any necessary permits and connect the system to the building's heating and hot water systems.

The benefits of thermal solar collectors are significant, as they can provide a significant portion of a building's heating and hot water needs. This can reduce the building's dependence on fossil fuels and lower energy costs. Thermal solar collectors can also help reduce the building's carbon footprint and promote sustainability.

It is important to note that the effectiveness of thermal solar collectors depends on several factors, such as the location and orientation of the collectors, the system design, and the weather conditions. In colder climates or during periods of low sunlight, supplemental heating may be required to meet the building's heating needs.

Overall, the installation of thermal solar collectors is valuable investment for public buildings looking to improve energy efficiency and promote sustainability. Proper planning and installation are critical to ensure maximum energy savings and a positive return on investment.

[11] available at: https://www.wrightrenewableheating.co.uk/wp-content/uploads/2021/08/solar-thermal-diagram.jpg

Hybrid PV thermal solar panels

Photovoltaic Thermal Solar Panels offer a compelling solution for maximizing energy output and efficiency by combining electricity generation and heat collection in a single technology. Their versatility, space efficiency, and dual-generation capability make them a suitable and eligible technology to be considered for energy efficiency projects across various sectors. In general, these panels generate electricity from sunlight while simultaneously harnessing heat energy for water or space heating.

To install hybrid PV - T solar panels, the building owner must first **evaluate the building's energy needs** (average users, need of hot water per person for hands washing, equipment like electrical heaters for generation of hot water etc.), the needs for electricity and available roof or ground space for the panels. A qualified installer can help design the system and select the appropriate panel technology, storage tanks, and other components. The installer will also need to obtain any necessary permits and connect the system to the building's heating and hot water systems.

The main advantages of this system are the dual energy generation, which maximize the energy output from a single installation, improved efficiency than separate systems and most importantly, space efficiency due to the utilization of the same space for both hot water demand and electricity.

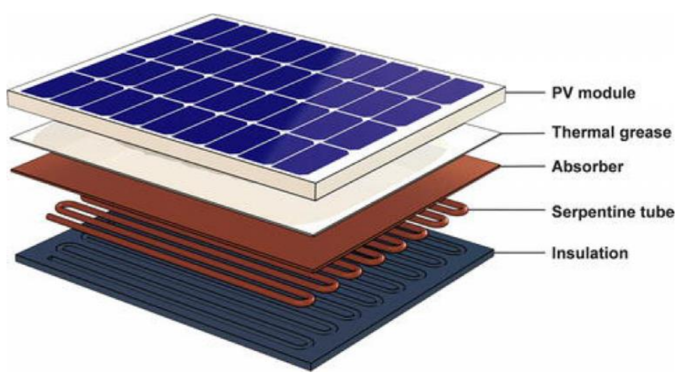


Figure 11. Hybrid PV thermal solar panel[12]

Solid biomass boiler

Replacing a traditional fossil fuel boiler with a solid biomass boiler is another effective way to improve energy efficiency in public buildings. Biomass boilers use **wood pellets, wood chips, or other organic materials** as fuel to produce heat. Biomass is considered a renewable energy source, as it comes from organic materials that can be replenished over time.

[12] Available at: https://climatebiz.com/wp-content/uploads/2021/03/pvt-1024x550.png

Figure 12. Solid biomass boiler[13]

To install a solid biomass boiler, the building owner must first evaluate the building's heating needs and determine the appropriate size and type of boiler. A qualified installer can help design the system and select the appropriate boiler, fuel storage, and other components. The installer will also need to obtain any necessary permits and connect the system to the building's heating and hot water systems.

The benefits of biomass boilers are significant, as they can provide reliable and efficient heating while reducing the building's dependence on fossil fuels. Biomass is also considered a carbon-neutral fuel, as the carbon emitted during combustion is offset by the carbon absorbed by the biomass during growth. This can help reduce the building's carbon footprint and promote sustainability.

It is important to note that biomass boilers require careful management to ensure efficient and clean combustion. The fuel must be stored and handled properly to prevent moisture and contamination, and the boiler must be maintained regularly to prevent ash buildup and ensure efficient operation.

Overall, the installation of a solid biomass boiler is a valuable investment for public buildings looking to improve energy efficiency and promote sustainability. Proper planning, installation, and maintenance are critical to ensure maximum energy savings and an increased RoI.

Air-to-water heat pump

The air-to-water heat pump is another consideration for public buildings. First of all, it is considered a renewable energy source and is reducing the carbon footprint of the building. It is versatile and can be used not only for heating but also for cooling and ventilation. It also improves the indoor air quality, and unlike combustion-based heating systems, air-to-water heat pumps do not emit any pollutants into the air, which can lead to improved indoor air quality and a healthier living environment. Probably one of the most important aspects of these heat pumps is the increased energy efficiency. Air-to-water heat pumps can provide a highly efficient means of heating a building by extracting heat from the outdoor air and transferring it to the indoor water-based heating system. This can result in lower energy bills and reduced greenhouse gas emissions compared to traditional heating systems.

[13] Available at: https://www.mdpi.com/energies/energies-14-04465/article_deploy/html/images/energies-14-04465-g001.png

Figure 13. Heat pump[14]

Ground-source heat pumps

The combination of Geothermal Heat Pumps and Photovoltaic panels presents a powerful approach to sustainable energy use. This integrated system leverages the thermal stability of the earth with solar-generated electricity, resulting in enhanced energy efficiency, reduced environmental impact, and increased energy independence. When properly designed, installed, and maintained, the synergistic benefits of this combined technology solution can contribute significantly to energy-efficient buildings and a greener future. By utilizing the relatively stable temperature of the ground, GHPs can achieve high energy efficiency and reduce the reliance on traditional heating and cooling methods that often consume more energy. When combined with PV panels, which generate electricity from sunlight, the integrated system maximizes the benefits of both technologies.

Heating system measures

There are several measures that can be implemented in the heating system of public buildings to improve energy efficiency, including the installation of thermostatic valves, thermostats, and energy-efficient radiators.

- Installation of thermostatic valves on individual radiators to control the temperature of each room independently. This will allow occupants to set the desired temperature for each room, which can help reduce energy waste by avoiding overheating or underheating.
- Installation of programmable thermostats to control the temperature of the entire building's heating system. A programmable thermostat can significantly reduce energy waste by automatically adjusting the heating system's settings to match the building's occupancy and usage patterns.
- Installation of thermal insulation of the piping system
- Installation of balancing valves

[14] Available at: https://ads-albania.com/wp-content/uploads/2018/10/61AF-022-105-High-Temperature-Air-to-Water-Heat-Pump-559x566.jpg

- Installation of energy-efficient radiators that are designed to provide the same level of comfort with lower energy consumption. This can be achieved by using advanced heating technologies or materials, such as low-temperature radiators or aluminum radiators with a larger surface area.
- Implementation of regular maintenance of the heating system, such as cleaning and tuning, to ensure optimal performance and energy efficiency.
- Consideration for upgrading the heating system to a more energy-efficient model, such as a condensing boiler or a heat pump. This may require a larger investment but can result in significant energy savings and lower operating costs over the long term.

These measures are considered as a package of measures aimed at the heating system for further consideration in this analysis. Some of the measures, as applicable, are excluded and their exclusion is noted appropriately throughout the analysis.

In conclusion, implementing measures aimed at the heating system of public buildings, such as thermostatic valves, thermostats, and energy-efficient radiators, can help reduce energy waste and lower energy costs while improving occupant comfort.

Measures for the Ventilation and Air-conditioning

Implementing energy-efficient measures for air conditioning systems is crucial for reducing energy consumption, operational costs, and environmental impact. Here are several measures that can be employed to enhance the energy efficiency of air conditioning systems:

- **Regular Maintenance.** Regularly inspect and maintain air conditioning equipment to ensure optimal performance. Clean or replace air filters, check refrigerant levels, and calibrate controls to prevent energy waste.
- **Renewable Energy Integration.** Power air conditioning systems with renewable energy sources like solar panels to reduce reliance on grid electricity.
- **Proper Sizing.** Ensure that the air conditioner is appropriately sized for the space it needs to cool. Oversized units’ cycle on and off frequently, leading to energy waste and discomfort.
- **Energy-Efficient Models.** Invest in air conditioners with high Energy Efficiency Ratio (EER) or Seasonal Energy Efficiency Ratio (SEER) ratings. These units consume less energy for the same cooling output.

Chapter III. Technical parameters considered for the implementation of energy efficient solutions and technologies

General information

In order to establish a comprehensive list of work, along with the required volume and construction parameters, it is crucial to consider various normative values and standards, particularly those related to design parameters and minimum performance requirements for buildings. The conditions and requirements taken into account in this study include **Design outdoor temperatures for heating and cooling systems**

Design outdoor temperature

The design outdoor temperatures for heating systems are defined in the Building Regulation M.01.02 – Energy performance of Buildings (MNC M.01.02:2016). The following table gives the average temperatures in the heating months.

Table 4. Average monthly temperatures in Moldova

Month	Average temperature in North Moldova [°C]	Average temperature in Central Moldova [°C]	Average temperature in South Moldova [°C]
October	7.11	7.31	7.51
November	3.2	3.9	4.3
December	-1.6	-0.9	-0.9
January	-4.4	-3.5	-3.2
February	-3.3	-2.5	-2
March	2	2.6	2.9

Design indoor temperature

The design indoor temperature for schools, cultural centers, and kindergartens in Moldova is regulated by the Building Regulation M.01.02 – Energy performance of Buildings (MNC M.01.02:2016) According to this standard, the recommended design indoor temperature for these types of buildings is as follows:

- Schools: The recommended design indoor temperature for classrooms is 20°C, while the recommended temperature for corridors, staircases, and other areas is 16°C.
- Kindergartens: The recommended design indoor temperature for kindergartens is 22°C.
- Office buildings: The recommended indoor temperature for hospitals is 20°C.

Heating Degree Days

The heating degree days (HDD) for a given location are calculated based on the number of degrees that the average daily temperature is below a certain base temperature (for this calculation, a base temperature of 18°C is used) over a given period of time, typically one year. HDD is used as a measure of the energy required to heat a building during the winter months. Moldova has a temperate continental climate, with cold winters and warm summers. The country is divided into three climate zones [Eu4Energy, 2020]:

- Northern region: 3,405 HDD
- Central region: 3,220 HDD
- Southern region: 3,150 HDD
- Chisinau: 3,220 HDD
- ATU Gagauzia: 3,150 HDD

Heating, cooling, and ventilation parameters[15]

The operating hours of various building systems, such as heating, lighting, and ventilation, depend on the specific use of the system and the type of building. Different buildings, such as kindergartens, cultural centers, hospitals, and schools, have varying requirements for system operation. The following working hour parameters are considered in the analysis:

1. Daily working hours for ventilation and heating systems:
    - 14 hours for schools, kindergartens, and cultural systems.
    - 24 hours for hospitals.
2. Daily working hours for cooling:
    - 12 hours for schools, kindergartens, and cultural systems.
    - 24 hours for hospitals.
3. Yearly working days for ventilation:
    - 262 days for kindergartens and cultural centers.
    - 193 days for schools.
    - 365 days for hospitals.
4. Number of air exchanges with natural ventilation:
    - 1.2 air exchanges per hour for kindergartens and cultural centers.
    - 1.8 air exchanges per hour for schools.
    - 2 air exchanges per hour for hospitals.

These parameters are crucial in determining the energy consumption and performance of the building systems. They reflect the specific operational requirements of different types of buildings, considering factors such as occupancy patterns, daily usage hours, and the need for ventilation or cooling. By accurately defining these parameters, it becomes possible to design and implement energy efficiency measures that align with the specific needs and usage patterns of each building type.

Solar irradiation

The following maps shows the PV power potential and the global horizontal irradiation in the Republic of Moldova.

[15] Rulebook for energy performance of buildings in Republic of North Macedonia (considered due to simmilarities of construction and period of construction of the buldings

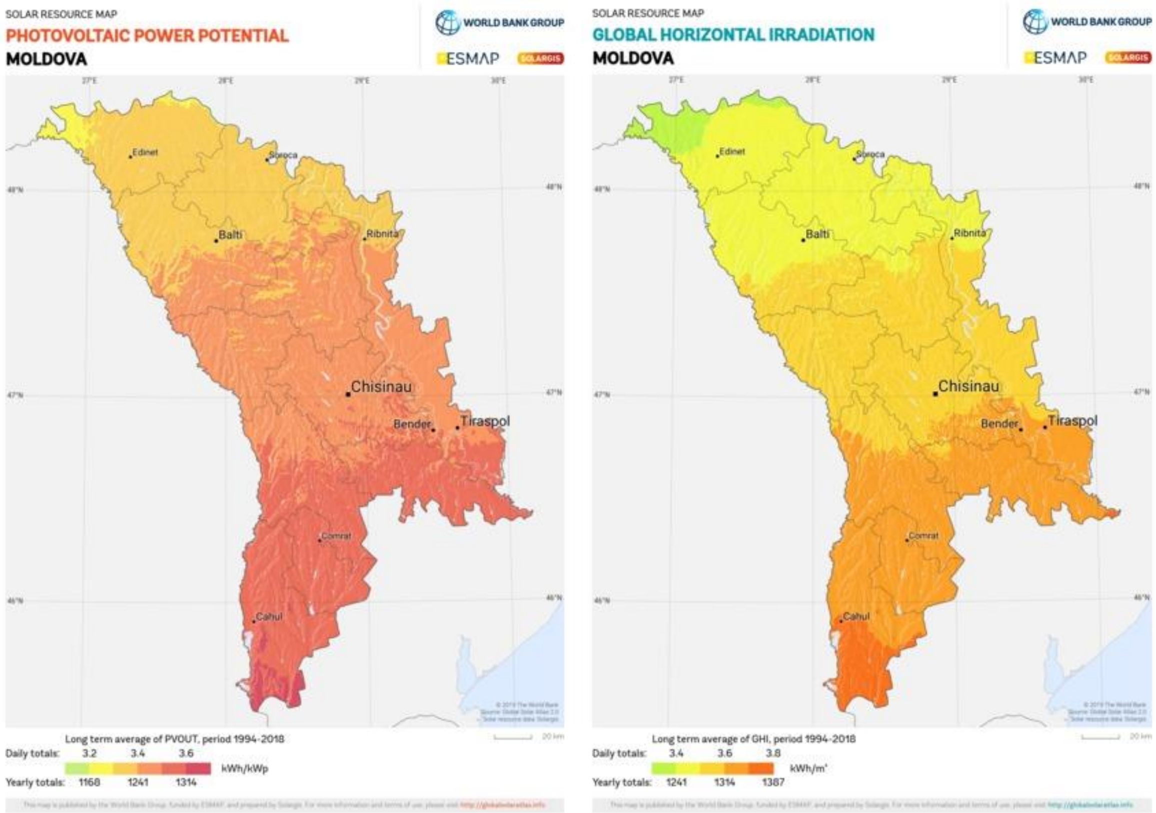


Figure 14. Photovoltaic electricity potential and global horizontal irradiation of Republic of Moldova[16]

Energy performance of buildings

According to the Energy Performance of Buildings Law No. 128 of 11.07.2014, the energy performance of buildings is classified as follows in the table below.

Table 5. Buildings energy performance classification, kWh/m² yr.

Type of building	A	B	C	D	E	F	G	**Actual values**
Unifamilial houses	≤ 47	47-93	94-190	191-287	288-359	360-431	> 431	~125
Multi-store buildings	≤ 22	22-44	45-102	103-159	160-199	200-239	> 239	~145
Offices buildings	≤ 25	25-49	50-94	95-138	139-173	174-207	> 207	~200
Social. Educational buildings	≤ 25	25-50	51-102	103-154	155-193	194-231	> 231	~180

[16] © 2020 The World Bank, Source: Global Solar Atlas 2.0, Solar resource data: Solargis

Minimum U-values for building envelope elements

Energy performance of buildings Law No. 128 of 11.07.2014 sets out minimum U-values for building envelope elements in Moldova, including external walls, windows, and roofs. U-value is a measure of the rate of heat transfer through a material, with lower values indicating better insulation.

Here are the minimum U-values required by the standard for building envelope elements in Moldova:

- External walls: The maximum U-value for external walls is 0.32 W/m²K
- Windows: The maximum U-value for windows is 1.5 W/m²K.
- Roofs: The maximum U-value for roofs is 0.2 W/m²K.

Minimum requirements for lighting

The minimum requirements for the lighting of rooms in public buildings are specified in the building standard MNC C.04.02:2017 Daylight and artificial lighting. As a general rule, rooms in public buildings should be lit by general lighting. The requirements for the level of lighting in rooms vary considerably depending on the purpose of the building, the use of the rooms, the type of activities that take place, the age and needs of the users (see table) and the energy efficiency of the lighting system.

Table 6. Standardised lighting indices for main rooms in public buildings[17]

Buildings	Illumination of work surfaces in general lighting, lux
Administrative buildings (ministries, departments, committees, prefectures, municipalities, directorates, construction and design organisations, scientific research institutes, etc.)	
Design rooms and chambers, design and technical drawing offices; analytical laboratories	500
Reading rooms; Computer rooms; Laboratories	400
Offices and workrooms, offices; Visitor and dispatch rooms; Xerox rooms; Cover and bookbinding rooms; Modelling, carpentry and repair workshops	300
Readers' catalogues, open access fund rooms; Conference and meeting rooms	200
Recreation, colour, hol	150
General, primary, secondary and higher general education institutions	
Technical and artistic drawing rooms	500
Classrooms, auditoriums, study rooms, laboratories; Computer and data processing rooms (on desks and benches); Manual work rooms	400
Metal and woodworking workshops; Hall floors; Teachers' rooms	300
Sports halls (on floors); Banqueting halls and auditoriums, cinemas	200
Indoor swimming pools; Recreation	150

The lighting of the main rooms of medical institutions shall be installed in accordance with the requirements of the hygienic rules of natural and artificial lighting provided for in the Sanitary Regulation

[17] Created in accordance with NCM C.04.02:2017, Annex G

on the hygienic conditions of medical institutions, approved by Government Decision No. 663 of 23.07.2010.

Table 7. Lighting of main rooms of medical institutions[18]

Buildings	Work surface illumination at full illuminance, lux
Types of rooms	
Children's inpatient classrooms; procedure and treatment rooms	500
Playrooms	400
Wards: pediatric wards, neonatal wards, intensive care, post-operative, mother and baby wards; feeding room; day ward	200
Adult wards	100
Operating theatre, resuscitation room, bandaging room, maternity wards	
Operating theatre; labor room, dialysis room, resuscitation rooms, bandaging rooms	500
Room for the installation of an artificial circulatory system, artificial kidney, etc.	400
The Pre-operative unit	300
The Blood Bank	200
Consultation, diagnosis and treatment units	
Surgical, obstetrician, gynaecologist, traumatologist, paediatrician, infectious disease specialist, dermatologist, allergist, dentist; examination rooms	500
Rooms for diagnostic radiology and therapeutic procedures	400
Reception rooms for doctors of other specialities, paramedics; Endoscopic procedure rooms; Functional diagnostics room, physiotherapy; Dynamic therapy room	300
Registration and dispatch; balneological therapy room, showers; massage rooms, therapeutic gymnastics, training rooms	200

Building stock considerations

Moldova's building stock, both public and residential, is characterised by low energy performance. Outside of Chisinau, there are over 7,500 public sector buildings, many of which are under heated and under occupied. The structural condition of many buildings is poor. Most of these blocks (about 54 per cent) are between 20 and 40 years old, approximately 30 per cent are 40-50 years old, 11 per cent are older than 50 years and only 5 per cent are relatively new (10-20 years). The majority of these buildings are characterized by low thermal insulation. [19]

[18] Created in accordance with NCM C.04.02:2017, Annex H.
[19] MOLDOVA BUILDINGS ENERGY EFFICIENCY PROGRAMME, EBRD, 2021

The average energy consumption of public buildings is of ca. 200 kWh/m2, with healthcare buildings' energy intensity being of ca. 400kWh/m2 - significantly higher than EU benchmarks of 110 kWh/m2 and 250 kWh/m2, respectively. [16]

Due to a serious earthquake in 1940, and the 2nd World War massive disasters, more than 70 per cent of building stock was destroyed. The existing building stock in the RoM was mainly built during the period of the former Soviet Union, starting from 1951 until the late 80's. Most of the buildings have an age of over 30 years. The most commonly used materials for construction, were clay 43 per cent (used in old single-family houses), limestones 33 per cent, concrete panels filled with expanded clay 16.9 per cent, hollow brick 7 per cent, and other materials (0.1 per cent).[20]

Even though these considerations are for residential buildings, due to lack of information, and similar period of construction, they are used in the analysis of the proposed measures.

Differences for the reference buildings

The following table shows the differences for the referent buildings based on their use, which needs to be considered when determining the materials and systems for implementation of the energy efficiency measures.

Table 8.Differences of the different types of reference buildings

Parameter	School	Kindergarten	Cultural centre	Hospital
Indoor temperature [°C]	20°C – classrooms 16°C - corridors	22	20	20
Working days/yr	193	262	262	365
Working hours/day	14	14	14	24
Air exchanges with natural ventilation [1/h]	1.8	1.2	1.2	2
Lightning [lux]	300	300	300	150-1,000

NOTE: All calculations presented in this analysis are indicative. It is necessary that energy audit and project design is prepared before implementation of the measures

Technical and technological aspects

It should be noted that if several of the listed measures are planned to be implemented over a period of time (not at once), the order of implementing the measures is important. For that reason, the following order is suggested:

- Replacement of the windows and doors
- Measures for indoor or outdoor lightning
- Thermal insulation of walls and roof
- Utilization of renewables

[20] Energy consumption in households, NBS, 2016, available at: https://statistica.gov.md/public/files/publicatii_electronice/Consum_energie_gospoda/Consum_energie.pdf

- Measures for the heating system and HVAC

For example, if the thermal insulation is installed before the replacement of the windows, the wall will be damaged. Above all, all measures are lowering the energy demand, and the heating system (HVAC as well) capacity. Accordingly, the heating system should be last measure, which will reduce the capacity of the equipment and the investment.

Due to the different requirements of the insulation material, the following table gives overview of the analysed solutions.

Table 9. Considered insulation materials for the building envelope

Material	Use	Thermal resistance – λ [W/mK][21]
Mineral wool	External wall / Roof / Basement	0.035
Expanded polystyrene	External walls / Roof	0.031
Polyurethane foam	External walls / Roof	0.035
Rigid foam boards	Basement	0.023
Spray foam	Basement	0.028

Thermal insulation of exterior walls

For the purpose of this analysis, as stated in the definition of parameters, a classical and widely used Limestone wall is used with:

3 cm interior mortar
40 cm limestone
No external finishing

The U-value of this type of external wall is calculated according to the ISO 6946:2017 standard, as follows:

$$U=1/R_{tot}$$

Where:

U – Thermal transmittance of the element (external wall in this case)
R_{tot} – The total thermal resistance of the layers of the element

$$R_{tot} = R_{st}+R_1+R_2+\ldots+R_n+R_{se}$$

R_{st} – Internal surface resistance = 8 W/m^2K
R_n – Thermal resistance of the layers of the element
R_{se} – External surface resistance = 23 W/m^2K

$$R= d/\lambda$$

d – Thickness of the layer [m]
λ – Design thermal conductivity of the material [W/mK]

[21] All λ are taken from the EBRD Green Technology Selector Tool for Republic of Moldova, available at: https://techselector.com/moldova-en/product-catalogue/insulation/building-insulation-materials.html?area_of_use=321

$\lambda_{limestone}$ = 0.73 W/mK
λ_{mortar} = 0.7 W/mK
Given the above elaborated estimations about the wall layers, the U value before the implementation of the measure is equal to:

$$U=1.32\ W/m^2K$$

Considering the minimum requirements for the U value of external walls, set up in the legislation of Republic of Moldova, the minimum thickness of the insulation material after significant reconstruction and for newly constructed buildings for this type of wall is:

Mineral wool (λ = 0.035 W/mK) – **10cm; U=0.28 W/m²K** / 5cm; U= 0.46 W/m²K

Expanded polystyrene (λ = 0.031 W/mK) – **≥8cm; U=0. 30 W/m²K** / 5cm; U= 0.42 W/m²K

Other types of walls are also considered, with similar results. The calculation of the U value, following the above determined methodology is presented in the following table.

Table 10. U value of commonly used walls (without *insulation) in* Moldova

	Walls type		Limestone	Reinforced concrete	Hollow brick
	a_i	W/m²K	8	8	8
	$1/a_i$		0.125	0.125	0.125
	a_e	W/m²K	23	23	23
	$1/a_e$		0.043	0.043	0.043
Interior plaster	d	[m]	0.03	0.005	0.03
	λ	[W/mK]	0.7	0.7	0.7
Limestone	d	[m]	0.4		
	λ	[W/mK]	0.73	0.73	0.73
Reinforced concrete	d	[m]		0.22	
	λ	[W/mK]	1.69	1.69	1.69
Hollow brick	d	[m]			0.25
	λ	[W/mK]	0.56	0.56	0.56
Aggregate Slag	d	[m]		0.08	
	λ	[W/mK]	0.76	0.76	0.76
Exterior plaster	d	[m]		0.05	0.03
	λ	[W/mK]	0.76	0.76	0.76
	Rk		0.759	0.477	0.697
	Rk_{Total}		0.759	0.477	0.697
	U		1.32	2.10	1.43

The following table shows the U values after implementation of the suggested measure.

Table 11. U values of most commonly used walls in Moldova after *installation* of thermal insulation

	Walls type		Limestone 10 cm insulation	Reinforced concrete 8 cm insulation	Hollow brick 10 cm insulation
	a_i	W/m^2K	8	8	8
	$1/a_i$		0.125	0.125	0.125
	a_e	W/m^2K	23	23	23
	$1/a_e$		0.043	0.043	0.043
Interior plaster	d	[m]	0.03	0.003	0.03
	λ	[W/mK]	0.7	0.7	0.7
Limestone	d	[m]	0.4		
	λ	[W/mK]	0.73	0.73	0.73
Reinforced concrete	d	[m]		0.22	
	λ	[W/mK]	1.92	1.69	1.92
Hollow brick	d	[m]			0.25
	λ	[W/mK]	0.4	0.4	0.56
Aggregate Slag	d	[m]		0.08	
	λ	[W/mK]	0.76	0.76	0.76
Insulation	d	[m]	0.1	0.1	0.1
	λ	[W/mK]	0.035	0.035	0.035
Exterior plaster	d	[m]		0.03	0.03
	λ	[W/mK]	0.76	0.76	0.76
	Rk		3.616	3.305	2.983
	Rk Total		3.616	3.305	2.983
	U		**0.28**	**0.30**	**0.28**

The following minimum technical criteria must be met by the thermal insulation material:

Mineral wool:

- Density of 135 kg/m3 or better.
- Thermal conductivity of 0.044 W/ mK or better.
- Compressive stress value at 10 per cent strain of thickness of 50 kPa or better.
- Incendiary Class A or better.

Extruded polystyrene:

- Density of 26 kg/m3 or better.
- Thermal conductivity of 0.035 W/ mK or better.
- Compressive stress value at 10 per cent strain of the thickness of 200 kPa or better.
- Incendiary class E or better.

Expanded polystyrene:

- Density of 15 kg/m3 or better
- Thermal conductivity of 0.038 W/ mK or better

- Compressive stress value at 10 per cent strain of the thickness of 70 kPa or better
- Incendiary class E or better

The common technical characteristics of the materials are shown in the following table.

Table 12.Characteristics of the thermal insulation materials

Material[22]		Characteristics [EBRD , n.d.]
Mineral wool		**Range of use:** Exterior wall, Façade, roof **Thermal transmittance (U-value):** 0.40 W/m²K **Thermal insulation resistance (R-value):** 2.50 m²K/W **Material:** Stone (basalt) **Thermal conductivity (λ-value):** 0.040 W/mK
Expanded polystyrene		**Range of use:** Exterior wall, Facade **Thermal transmittance (U-value):** 0.15 W/m²K **Thermal insulation resistance (R-value):** 6.45 m²K/W **Material:** Expanded polystyrene (EPS) **Thermal conductivity (λ-value):** 0.031 W/mK

During the installation phase of this measure, the following general list and volume of work is required:

It should be noted that the thermal insulation materials are installed as a Thermal insulation system. They are usually installed with:

- Adhesives
- Reinforcements
- Coatings (render, waterproofing etc.)
- Mechanical fixing devices
- Membranes (vapor proof and waterproof)
- other ancillary materials (mastics, corner strips, joint-covers etc.)

[22] Images available at:
http://mima.info/about-mineral-wool/what-is-mineral-wool/
https://ehsmith.co.uk/wp-content/uploads/00001248-1.jpg
https://www.advancedseals.co.uk/wp-content/uploads/bb-plugin/cache/convaluted-packaging-polyurethane-foam-sheets-650x650-panorama.jpg3

Masonry works

Purchase of materials for thermal insulation of walls and installation, together with finishing works: Mineral wool or expanded polystyrene (Styrofoam) with a thickness of 100 mm, together with the necessary fittings for installation in accordance with existing standards for such systems and final layers (reinforcement net, waterproof layer, finishing mortar) along with repairs (patching) the walls

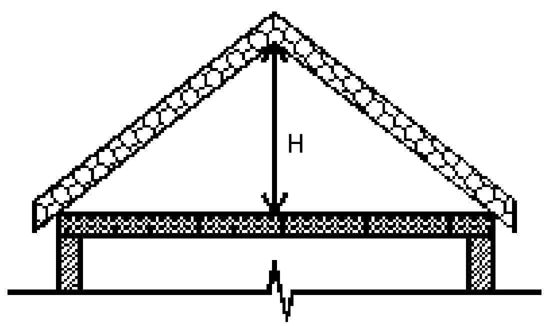
Auxiliary works

scaffolding, site clearance and construction waste removal

Thermal insulation of roof

In the case of the measure for installation of thermal insulation of the roof, considering that the roof has a contact with the outside air or is not ventilated, all consideration presented in the Measure for thermal insulation of external walls are in effect. With the assumption that the separator between the heated and the unheated space is a concrete slab with thickness of 20cm and with height of H=1m (R of unventilated air form Table 2 form ISO 6946), the U value of the roof before implementation of measures is:

$$U=2.12\ W/m^2K$$



Considering the minimum requirements for the U value of external walls, set up in the legislation of Republic of Moldova, the minimum thickness of the insulation material after significant reconstruction and for newly constructed buildings for this type of wall is:

Mineral wool (λ = 0.035 W/mK) – **15cm; U=0.20 W/m²K** / 10cm; U= 0.30 W/m²K

Expanded polystyrene (λ = 0.031 W/mK) – **15cm; U=0.19 W/m²K** / 10cm; U= 0.27 W/m²K

Polyurethane foam (λ = 0.035) - **15cm; U=0.20 W/m²K** / 10cm; U= 0.30 W/m²K

The technical characteristics of the materials are the same as the ones for the external wall.

The following minimum technical criteria must be met by the thermal insulation material:

Expanded polystyrene:

- Density of 30 kg/m3 or better;
- Thermal conductivity of 0.037 W/ mK or better;

- The value of the compressive stress at 10 per cent deformation of the thickness of 150 kPa or better (depending on the weight of the roof);
- Incendiary class E or better.

Extruded polystyrene:

- Density of 35 kg/m3 or better;
- Thermal conductivity of 0.035 W/ mK or better;
- The value of the compressive stress at 10 per cent deformation of the thickness of 300 kPa (or better;
- Incendiary class E or better.

Mineral wool:

- Density of 130 kg/m3 or better;
- Thermal conductivity of 0.044 W/ mK or better;
- Compressive stress value at 10 per cent deformation of the thickness of 45 kPa or better;
- Incendiary Class A or better.

Three different types of installation are considered based on the building type.

Sloping roof: insulation of the attic floor - an economical option

This measure includes laying of thermal insulation material on the outside of the concrete slab – the attic floor (mineral wool) together with finishing elements like access roads and anti-vapor film and anti-condensation film.

During the installation phase of this measure, the following general list and volume of work is required for insulating the ceiling from the outside of the concrete slab:

Masonry works

Purchase of materials for thermal insulation of the ceiling and installation, together with all finishing elements in accordance with existing standards for such systems. Installation of the materials:

- Installing the anti-vapor film
- Laying of thermal insulation material (mineral wool 10 cm)
- Installing the anticondensation film
- Construction of access roads

Auxiliary works

scaffolding, site clearance and construction waste removal

Flat roof - Insulation on the exterior surface

In the case of a flat roof, insulating the exterior surface is also popular solution. It is implemented similar as the insulation of the attic floor described previously. It should be noted that strong adhesive should be used on the insulation material.

Figure 15. Flat roof - insulation of the exterior surface[23]

Masonry works

Purchase of materials for thermal insulation of the ceiling and installation, together with all finishing elements in accordance with existing standards for such systems. Installation of the materials:

- Installing the anti-vapor film
- Laying of thermal insulation material (mineral wool 10 cm)
- Installing the anticondensation film
- Mortar or other finishing element
- 2-layer bituminous membrane

Auxiliary works

scaffolding, site clearance and construction waste removal

Basement thermal insulation works

Several assumptions are made in order to simulate real buildings and conditions. For example, the basement is assumed that is fully underground and the layers of the wall are the same as the external walls.

The main difference when considering the insulation material is that the chosen one needs to have bigger resistance of moisture. For that reason, the considered insulation materials are rigid foam boards and spray foam.

Additionally, considering the calculation of the U value, the element External surface thermal resistance or R_{se} is neglectable, because the elements are not in contact with the outdoor air.

Given these assumptions, the U value before the implementation of the measure is:

[23] Image available at: https://reliable-roofing.com/what-kind-of-insulation-used-flat-roof/

U = 1.30 W/m²K

Rigid foam boards (λ = 0.023 W/mK) – **≥ 8cm; U=0.24 W/m²K** / 5cm; U= 0.34 W/m²K

Spray foam (λ = 0.028) - **≥ 8cm; U=0.28 W/m²K** / 5cm; U= 0.39 W/m²K

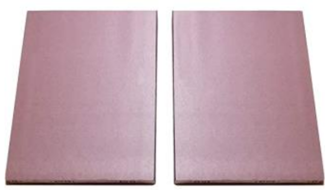
The following minimum technical criteria must be met by the thermal insulation material:

Extruded polystyrene

- Density of 26 kg/m3 or better;
- Thermal conductivity of 0.035 W/ mK or better;
- The compressive stress value at 10 per cent deformation of the thickness of 200 kPa or better;
- Incendiary class E or better.

The common technical characteristics of the materials are shown in the following table.

Table 13.Common characteristics of roof insulation materials

Material[24]		Characteristics [EBRD , n.d.]
Rigid foam boards		**Range of use:** Floor, Ceiling, Exterior wall, Interior wall, Heating system, Facade, Roof, Wall **Thermal transmittance (U-value):** 0.23 W/m²K **Thermal insulation resistance (R-value):** 4.35 m²K/W **Material:** Polyisocyanurate (PIR) **Thermal conductivity (λ-value):** 0.023 W/mK
Spray foam		**Range of use:** Floor, Ceiling, Exterior wall, Interior wall, Heating system, Facade, Roof, Wall **Thermal transmittance (U-value):** 0.35 W/m²K **Thermal insulation resistance (R-value):** 2.86 m²K/W **Material:** Polyurethane (PUR) **Thermal conductivity (λ-value):** 0.028 W/mK

Replacement of windows and external doors

When considering replacement of the doors and windows, the new windows should meet the minimum criteria set up in the Moldovan regulation, as stated at the beginning of the chapter. Those criteria, both

[24] Images available at:
https://images-na.ssl-images-amazon.com/images/I/71se4loMO1L._AC_UL600_SR600,600_.jpg
https://www.zestenergy.net/uploads/1/0/0/8/100819746/published/sprayfoaminsulation.jpg?1617570510

of the frame and glass, as well as the window as a whole should have certificate from accredited laboratory from the country or recognized international laboratories in Moldova whit which, they guarantee the U value of this element.

It should be noted that due to variety of thickness of the mortar, all measures need to be checked onsite after the dismantling of the existing windows.

The following minimum technical criteria must be met by the windows and doors are:

- The total thermal conductivity of the windows/doors, including the frames, must be:
  - for windows 1.5 W/(m²/K), or better
  - for doors and 1.9 W/(m²/K), or better.
- Non-recycled PVC frames with a minimum number of 5 air chambers, reinforced with a metal profile with a thickness of 1.2 mm, covered with a layer of plastic material, without thermal bridges. The minimum thickness of the walls of PVC profiles should be Class A, that is: the thickness of the faces seen from the perimeter of the profile from the outside and inside is greater than or equal to 2.8 mm; the thickness of the structural faces (through which the anchoring elements of the frame pass) greater than or equal to 2.5 mm; the thickness of the internal separation walls greater than or equal to 2.0 mm.
- 4mm or better double glass made of low emissivity coated glass.
- Sound insulation of 35 dB, or better, or equivalent to class III, or better.
- Air permeability to correspond to class 4 or better
- Watertightness to meet class 7A or better.
- Wind load resistance to meet class C3 or better.

The common technical characteristics of the materials are shown in the following table.

Table 14.Common technical characteristics of energy efficient windows

Type of energy efficient window[25]			Characteristics [EBRD , n.d.]
Wood frame	2 panes		**Thermal transmittance (U-value):** 1.20 W/m²K **Thermal insulation resistance (R-value):** 0.83 m²K/W **Filling:** Argon
	3 panes		**Thermal transmittance (U-value):** 1.10 W/m²K **Thermal insulation resistance (R-value):** 0.91 m²K/W **Filling:** Air

[25] Images available at:
https://efficientwindows.org/wp-content/uploads/2020/10/wooddouble.jpg

	3 panes / Argon		**Thermal transmittance (U-value):** 1.10 W/m²K **Thermal insulation resistance (R-value):** 0.91 m²K/W **Filling:** Argon
Aluminium frame	2 panes		**Thermal transmittance (U-value):** 1.40 W/m²K **Thermal insulation resistance (R-value):** 0.71 m²K/W **Filling:** Air
	3 panes		**Thermal transmittance (U-value):** 1.30 W/m²K **Thermal insulation resistance (R-value):** 0.77 m²K/W **Filling:** Air
	Argon filled		**Thermal transmittance (U-value):** 1.10 W/m²K **Thermal insulation resistance (R-value):** 0.91 m²K/W **Filling:** Argon
PVC frame	2 panes		**Thermal transmittance (U-value):** 1.40 W/m²K **Thermal insulation resistance (R-value):** 0.71 m²K/W **Filling:** Air
	3 panes		**Thermal transmittance (U-value):** 1.20 W/m²K **Thermal insulation resistance (R-value):** 0.83 m²K/W **Filling:** Air
	Argon filled		**Thermal transmittance (U-value):** 0.83 W/m²K **Thermal insulation resistance (R-value):** 1.20 m²K/W **Filling:** Argon

During the installation phase of this measure, the following works and steps need to be considered:

Preparatory works

Dismantling of the existing window plates, together with loading and transport to a landfill

Dismantling of the existing window planks from inside, together with loading and transport to landfill

Dismantling of the existing window grilles and their storage until re-installation

Removal of existing windows and doors

Locksmith works

The lock scheme from the project design is used as a guideline, but before the installation all the measures have to be checked onsite. The installation of the windows have to be by self-screwing bolts, and the connection between the walls and the frames have to be repaired according the existing standards. The price must include the accessories and the profiles with coefficient of heat conductivity of the window “U_w“ equal or lower than 1.5W/m^{2}K with double glazing, one glazing has to be with low-e coating, with „U_f“ =1.1W/m^{2}K with thickness 4/12/4mm and proper bindings. The installed parts must attain certificate for guarantee of the performance issued by an authorized institution.

Assembly, transport and installation of a new PVC windows according to the design documentation

Finishing work

Purchase of materials for leveling and painting OF the walls around windows and doors with ecological colors

Energy efficiency works in indoor lighting.

When considering a measure that includes energy efficient indoor lightning, it is essential to keep the necessary lighting conditions as set up in the national regulation for different types of buildings.

For consideration of replacement bulbs for implementation of this measure, the luminous flux and the colour temperature characteristics of the light bulb are compared. Common incandescent bulb with capacity of 60 W has a luminous flux of around 800 lm and colour temperature of around 2,700K, so energy efficient light sources with similar flux are considered. The following table gives overview of the common characteristics of replacement LED.

The minimum technical requirements for the lightning fixtures are:

- Lighting fixtures equipped with LED type sources.
- Luminaire luminous efficiency of at least 100 lm/W, or better
- Color temperature of less than 6,000K
- Color rendering index ≥80.
- Lifespan of 20,000 hours or better.
- Degree of protection of the optical compartment (minimum) IP20, or better.
- Impact resistance level of minimum IK05 or better.
- Luminaire warranty of 2 years or better.

Table 15.Common characteristics of indoor LED

Characteristic[26][27]	Value
Technology	LED
Form	T8 tube
Capacity	9 W
Luminous efficiency of the light source	110 lm/W
Luminous flux	900 lm
Colour temperature	3,000 K
Colour Rendering Index	80 CRI

The list and volume of total reconstruction of the lightning system typically includes:

Preparatory work

Design and planning: Based on the audit, a lighting designer or engineer may need to design a new lighting system that meets the specific needs of the space while maximizing energy efficiency.

Procurement: Once the design is complete, the necessary lighting fixtures, bulbs, ballasts, and other components will need to be purchased.

Removal of old lighting fixtures: Existing lighting fixtures will need to be removed, including any wiring or mounting hardware and deposited in a landfill.

Replacement works

Installation of new fixtures: The new lighting fixtures will need to be installed according to the design plan. This may involve running new wiring, mounting the fixtures, and connecting any necessary controls or sensors.

Connection to power source: The new lighting system will need to be connected to the building's electrical system, either directly or through a control system.

Finishing work

Testing and commissioning: Once the installation is complete, the new lighting system will need to be tested and commissioned to ensure that it is functioning properly and meeting performance goals.

It should be noted that the specific volumes of work involved will depend on the size and complexity of the lighting system, as well as the specific goals of the project. For example, a project that involves replacing a few fixtures with LED bulbs may be relatively simple, while a project that involves redesigning the entire lighting system and installing new fixtures, wiring, and controls may be much more complex and involve more extensive work.

[26] The image is available at:
https://uniel.info/files/foto/UL-00006697-3.jpg

[27] All characteristics are taken from the EBRD Green Technology Selector Tool for Republic of Moldova, available at:
https://techselector.com/moldova-en/product-catalogue/insulation/building-insulation-materials.html?area_of_use=321

Energy efficiency works in outdoor lighting

The outdoor lightning, opposite to the indoor lightning can be used by need, for example when there are people in vicinity and during the night. Thus, it is necessary that appropriate systems are in place.

As the case for the indoor lightning, two types of lights will be considered, based on the same criteria. The following table compares high pressure sodium lights and LED.

Table 16. Characteristics of high-pressure sodium lights and LED

Material[28]		Characteristics [EBRD , n.d.] - type 1 – smaller flux	Type 2 – bigger flux
High pressure sodium lamp		**Capacity** 150 W **Luminous flux** 1,700 lm **Colour temperature** 2,000 K **Colour Rendering Index** 25 CRI **Luminous efficiency of the light source** 113 lm/W	**Capacity** 400 W **Luminous flux** 56,500 lm **Colour temperature** 2,000 K **Colour Rendering Index** 25 CRI **Luminous efficiency of the light source** 141 lm/W
LED		**Capacity** 154 W **Luminous flux** 17,150 lm **Colour temperature** 2,700 K **Colour Rendering Index** 80 CRI **Luminous efficiency of the light source** 111 lm/W	**Capacity** 500 W **Luminous flux** 60,000 lm **Colour temperature** 4,000.00 K **Colour Rendering Index** 80 CRI **Luminous efficiency of the light source** 120 lm/W

The following volume of work is necessary for the implementation of this measure:

Preparatory work

Conducting a lighting audit to identify areas for improvement.

Selecting and purchasing energy-efficient lighting fixtures that are appropriate for the specific application.

[28] Images available at:
https://www.lowesprosupply.com/UserFiles/large/415315.jpg
https://www.dhresource.com/0x0/f2/albu/g8/M01/C5/B0/rBVaV1y4erSATqgAAAFcSUCUaGU235.jpg

Reconstruction work

Installing efficient and appropriate lighting fixtures / bulbs.

Installing motion sensors or timers to control when lights are turned on and off.

Installing shields or other accessories to direct light where it is needed and reduce glare and light pollution.

Installing monitoring systems to track energy consumption and identify areas for improvement.

Finishing work

Testing and commissioning: Once the installation is complete, the new lighting system will need to be tested and commissioned to ensure that it is functioning properly and meeting performance goals.

Construction and technical requirements for the installation of equipment

Renewable energy sources valorization works

Solar thermal collectors

Solar thermal collectors are designed to absorb sunlight and convert it into thermal energy, which can then be used for heating water or air. When installing solar thermal collectors, there are several construction-technical requirements to consider:

Orientation and tilt - Solar thermal collectors should be installed facing south in the Northern Hemisphere to maximize exposure to sunlight. The tilt of the collectors should also be optimized based on the latitude of the location.

Shading - Solar thermal collectors should be installed in a location that is not shaded by trees, buildings, or other obstructions, as shading can significantly reduce the amount of sunlight that is collected.

Mounting - Solar thermal collectors can be mounted on the roof or on a ground-mounted structure. The mounting system should be designed to withstand wind and snow loads in the area.

Piping and insulation - The piping connecting the solar collectors to the storage tank or heating system should be well-insulated to minimize heat loss. The piping should also be sized appropriately to minimize pressure drop.

Heat storage - A storage tank is typically used to store the heated water or air generated by the solar collectors. The tank should be well-insulated to minimize heat loss.

Freeze protection - In cold climates, the solar thermal system should be designed to prevent freezing of the fluid in the collectors and piping. This can be achieved through the use of antifreeze or by draining the system during periods of cold weather.

Control and monitoring - The solar thermal system should be equipped with sensors and controls to optimize performance and prevent overheating or other issues. A monitoring system can also be used to track system performance and identify any issues that may arise.

The specific list and volumes of work for the installation of a solar thermal collectors will depend on the size and complexity of the system, as well as the specific requirements of the building and local regulations.

The minimum system requirements that must be met are:

- Solar collector system with forced circulation
- Power (according to the technical project).
- Absorption coefficient of 0.94 or better
- Bivalent hot water tank.
- The energy efficiency class, according to the energy label, of the solar collectors for heating water from the heating energy efficiency classes to be A+
- Collector efficiency of 77 per cent or better
- The energy efficiency class, according to the energy label, of the hot water tanks (boiler) should be B.
- Minimum collector warranty period of 5 years.
- Minimum tank warranty period of 2 years.
- The duration of operation of the collectors of at least 15 years.

PV

The installation of photovoltaic (PV) systems requires certain construction-technical requirements to ensure safe and efficient operation. Some of the key requirements are:

Roof structure - The roof on which the PV panels will be mounted should be strong enough to support the weight of the panels and any additional equipment. The roof should be made of a durable material and in good condition.

Orientation and tilt angle - The orientation and tilt angle of the PV panels should be optimized for maximum sunlight exposure. Ideally, the panels should be facing south and tilted at an angle between 30 and 45 degrees.

Shading - The PV panels should be installed in a location where there is minimal shading, as shading can significantly reduce the output of the system. Trees, buildings, and other objects that could cause shading should be avoided.

Electrical system - The electrical system of the building should be evaluated to ensure it can safely accommodate the PV system. This may require upgrades to the electrical panel, wiring, and grounding system.

Inverter - The inverter is a critical component of a PV system, as it converts the DC electricity generated by the panels into AC electricity that can be used by the building. The inverter should be of high quality and appropriately sized for the system.

Mounting system - The mounting system should be designed to securely attach the PV panels to the roof or other structure. The system should be made of high-quality materials that are resistant to corrosion and weathering.

Permitting and inspection - The installation of a PV system typically requires permits and inspections from local authorities. The installation should comply with all applicable codes and regulations.

The specific list and volumes of work for the installation of a PV system will depend on the size and complexity of the system, as well as the specific requirements of the building and local regulations. Generally, the installation process includes design and engineering, procurement of equipment, construction of mounting structures and electrical system, installation of the panels, and commissioning and testing of the system.

For example, the following calculation shows the potential of the system for a roof area of 1000m^2.

Table 17. Annual energy production of a PV system

Solar irradiation	**kWh/m^2**	**1314**
Area for 1kW capacity of the panels	m^2	4.74
Performance ratio	[-]	0.80
Electric efficiency	%	21.08
Roof area	m^2	1,000
Area utilization factor	[-]	0.5
Net useful area	m^2	500
Total installed capacity of the system	kW	105.49
Annual energy production	**kWh/year**	**110,796**

Where the annual energy production is calculated base on the following formula:

Annual energy production = Net useful area* Electric efficiency* Solar irradiation* Performance ratio [kWh/year]

The performance ratio includes all the losses in the system, such as losses in the inverter, temperature losses, cable losses etc.

For the purposes of the calculation, the following PV panel available at the market in the Republic of Moldova is considered:

Table 18. Characteristics of a PV panel

Characteristic[29] [30]	Value

[29] The image is available at:
https://uniel.info/files/foto/UL-00006697-3.jpg
[30] All characteristics are taken from the EBRD Green Technology Selector Tool for Republic of Moldova, available at: https://techselector.com/moldova-en/product-catalogue/insulation/building-insulation-materials.html?area_of_use=321

Size of PV panel	2.16 m²
Electric efficiency	21.08 %
Capacity	455 W

The minimum criteria for a PV panel is:

- Rated power (will be indicated according to the project)
- Photovoltaic panel with an efficiency of 21 per cent or better.
- Operation in the temperature range of −40°C to +85°C, or better.
- Maximum mechanical wind load to 2,400 Pa, or better.
- Maximum mechanical load in snow is to 5,400 Pa, or better.
- Tempered glass with high transmission coefficient and anti-reflective coating, or better.
- The mounting structure should be aluminum parts or stainless-steel parts, or better.
- Protection requirements IP68 or better.
- 12-year panel warranty or better.
- 25-year productivity guarantee with a maximum yield degradation of 15.2 per cent or better.

Hybrid PV thermal solar panels

The typical characteristics of a PV/T system are shown in the following table.

Table 19.Common characteristics of a PV/T panel

Characteristics[31]	Value
Electric power	280W
Thermal power	648W

The installation of hybrid PV thermal solar panels includes the following steps:

Preparatory works

Assessment - Conduct a thorough assessment of energy needs, available sunlight, and heat demand to determine the feasibility and potential benefits of PV/T panels.

Design and Sizing - Design the PV/T system to meet electricity and heat requirements. Consider factors such as panel orientation, tilt, and integration with existing systems.

Installation works

[31] https://www.solarguide.co.uk/solar-pvt#/

Installation - Install the PV/T panels on rooftops, facades, or ground-mounted structures. Ensure proper placement for optimal energy capture and performance.

Integration - Integrate the generated electricity and heat into the building's energy systems, including electrical grids, heating systems, and water supply.

Solid biomass boiler

It is assumed that this measure consists of only replacement of the boiler. That means that there is an adequate boiler room that meets the legislative and normative requirements, there is an adequate chimney and piping – distribution lines. There are no specific technical-construction requirements except the adequate capacity of the boiler.

The common technical characteristics of an efficient solid biomass boiler are shown in the following table.

Table 20. Technical characteristics of an efficient solid biomass boiler

Characteristics [EBRD , n.d.]		Value
Thermal efficiency		90.85 %
Capacity		51.60 kW
Output		Heat
Fuel		Pellets
Energy label (energy efficiency class)		A++

The minimum criteria for the solid biomass boiler (pellets) is:

- The efficiency of the boiler must not be less than 85 per cent.
- Maximum temperature of the thermal agent of 85 o C
- Maximum allowed pressure of 2.5 bar
- Maximum test pressure of 3 bar.
- Equipped with fixed or modular speed fan, and combustion chamber.
- Control panel equipped with a set of temperature sensors for controlling the circulation pump of the heating system and the boiler fan.
- Steel heat exchanger, cylindrical and swirl type .
- Flame reverse protection device to the fuel tank.
- Equipped with cleaning tools.
- Autonomy when operating at nominal load of at least 10 hours.
- Electrical protection class at least IP 20, according to EN 60529.
- Minimum boiler warranty period of 5 years.
- Boiler service life of at least 10 years.

The installation of a new solid biomass boiler will generally involve the following steps:

Preparatory works

Removal of an old boiler - The first step is to remove the existing boiler from its location, disconnect it from the chimney and heating pipes, and dispose of it properly.

Preparation of the installation site - The area where the new boiler will be installed needs to be prepared, which may include cleaning and repairing the chimney, checking the suitability of the existing heating pipes, and ensuring that the new boiler will fit properly in the available space.

Installation works

Installation of a new boiler - The new biomass boiler will be installed in the prepared location and connected to the existing heating pipes and chimney. The installation should follow the manufacturer's instructions and comply with local building codes and regulations.

Finishing works

Commissioning and testing - Once the new boiler is installed, it needs to be commissioned and tested to ensure that it is functioning properly and safely. This may involve checking the fuel supply, adjusting the controls, and testing the emissions.

Training and handover: The final step is to train the building maintenance staff on how to operate and maintain the new biomass boiler and to hand over any necessary documentation and warranties.

Air-to-water heat pump

The main consideration when installing air-to-water heat pump in the capacity of the pump. The chosen heat pump needs to have adequate capacity for the heating needs of the building.

Additionally, in general, air-to-water heat pumps work best with underfloor heating systems or low-temperature radiators, which require water at temperatures between 30-50°C. if the building is equipped with high-temperature radiators (usually found in older buildings), it may not be the most efficient heating solution, as the water output temperature of the heat pump may not be high enough to adequately heat the space. In that case, a reconstruction of the heat distribution and emission system should be performed, and considering existing buildings, for example with underfloor heating, the investment is expected to be higher than with a new construction of building.

The minimum technical requirements for air-to-water heat pumps are:

- Air-to-water heat pumps (monobloc or split)
- Nominal power (according to the technical project)
- Seasonal space heating energy efficiency class of heat pumps and space heating heat pump installations for low temperature application A+++ (35°C) and A++ (55°C), or better.
- Nominal Coefficient of Performance (COP) for space heating for low temperature application (35°C) of 4.8 or better
- Space heating seasonal coefficient of performance (SCOP) for low temperature application (35°C) of 4.6 or better
- Nominal coefficient of performance (COP) for space heating (55°C) of 3 or better
- Seasonal coefficient of performance (SCOP) for space heating (55°C) – 3.4

- Minimum pump warranty period of 3 years.

The following table presents the common characteristic of an air-to-water heat pump.

Table 21. Characteristic of an air-to-water heat pump

Characteristics [EBRD , n.d.]		Value
Coefficient of performance (COP)		4.60 COP
Heating capacity		45.00 kW
Cooling capacity		49.00 kW
EU energy label		A+++
Seasonal COP		5.00

With that in mind, the installation of an air-to-eater heat pump in public building should require the following technical-construction parameters:

Location - The heat pump should be installed in a well-ventilated area, with sufficient space around it for maintenance and repair work. The location should also be easily accessible for transport and installation of the unit.

Size - The size of the heat pump should be appropriate for the heating needs of the building, taking into account the climate conditions, the size of the building, and the thermal insulation levels. Oversized or undersized units can result in poor energy efficiency and increased energy costs.

Water tank - An air-to-water heat pump requires a water tank to store and distribute the heated water. The size of the tank should be appropriate for the heating needs of the building, and the tank should be insulated to prevent heat loss.

Controls - The heat pump requires appropriate controls to regulate the temperature and ensure efficient operation. The controls should be easily accessible and user-friendly.

Ground-source heat pump with PV integration

The common characteristics of the ground-source heat pump are shown in the following table.

Table 22. Characteristic of a ground-source heat pump

Characteristics [EBRD , n.d.]		Value
Coefficient of performance (COP)		4.90 COP
Seasonal COP		5.00
Heating capacity		22.8 kW
Cooling capacity		22 kW

EU energy label		A+++
Seasonal COP		5.00

The installation of a new Ground-source heat pump with PV integration will generally involve the following steps:

Site Assessment - Assess the building's energy needs, available land, and geothermal suitability for ground loop installation.

System Design - Design the ground-source system based on heating and cooling load requirements. Integrate the design with PV panels to maximize energy production and consumption synergy.

Installation - Install the ground-source system's components, including ground loops, heat pumps, and controls. Install PV panels on rooftops or ground mounts, ensuring optimal orientation and tilt.

Integration and Controls - Integrate the ground-source system with the building's heating/cooling distribution systems. Implement intelligent controls to manage the interaction between ground-source system and PV panels.

Testing and Commissioning - Thoroughly test the integrated system to ensure seamless operation, efficient energy transfer, and effective controls.

Thermal energy efficiency works

The thermal efficiency measures include several low investment measures with significant energy savings potential, especially valid for older buildings and heating systems. They are also easy to implement in existing systems.

The following list describes the technical-construction parameters that needs to be considered when implementing such measures.

Thermostats – Applicable with heat pumps and other systems with capability of zone control. When selecting thermostats, it is important to choose ones that are compatible with the heating system and can handle the required load. The accuracy and sensitivity of the thermostat are also important factors to consider.

Thermostatic valves - The size and type of thermostatic valves should be selected based on the size of the pipes and the heating system. It is important to choose valves that are durable and can handle the required flow rate and temperature range.

Insulation of pipes - The type and thickness of insulation used for pipes depend on the size and location of the pipes. For example, pipes that are exposed to cold temperatures or are located in unheated areas will require thicker insulation. It is important to use insulation that has a low thermal conductivity to minimize heat loss.

Circulation pumps - The size and capacity of the circulation pumps should be selected based on the flow rate and pressure requirements of the heating system. Energy-efficient pumps should be selected to minimize energy consumption.

Balancing valves - Balancing valves are used to regulate the flow rate of water in the heating system. The size and type of balancing valves should be selected based on the size and pressure requirements of the heating system.

Expansion tanks - Expansion tanks are used to compensate for the expansion and contraction of water in the heating system. The size and capacity of the expansion tanks should be selected based on the size of the heating system and the volume of water it contains.

Pressure relief valves - Pressure relief valves are used to prevent excessive pressure from building up in the heating system. The size and capacity of the pressure relief valves should be selected based on the size and pressure requirements of the heating system.

Ventilation and air-conditioning system efficiency works

Enhancing the efficiency of air conditioners involves a combination of simple yet impactful measures. Regular maintenance, such as cleaning or replacing air filters, ensures unrestricted airflow and optimal performance. Installing programmable thermostats enables tailored cooling schedules, reducing energy use during unoccupied periods. Shading windows and maintaining proper insulation prevents heat gain, thereby lessening the workload on air conditioners. Smart technology, like inverter models and smart thermostats, ensures precise temperature control and minimizes energy waste. Educating users about setting comfortable yet efficient temperature levels and avoiding unnecessary usage further contributes to sustainable cooling practices.

The minimum requirements for ventilation and air conditioning systems are:

- Nominal power (to be determined according to the technical project)
- Energy efficiency class, cooling, for air conditioners minimum A++
- Energy efficiency class, heating, for air conditioners minimum A+
- Seasonal Energy Efficiency Rating (SEER) for cooling of 6.1 or better
- Seasonal coefficient of performance (SCOP) for heating of 4 or better
- Cooling Energy Efficiency Rating (EER) of 3.6 or better
- Nominal coefficient of performance (COP) for heating of 3.6 or better
- Minimum warranty period of 5 years.

The common characteristics of the air conditioner are shown in the following table. [32]

Table 23. Characteristic of an air conditioner

[32] Image available at: https://www.eedesignit.com/w-content/uploads/2016/07/air-conditioners.jpg

`Characteristics [EBRD , n.d.]		Value
Cooling capacity		2.85 kW
EU Energy label		A++
Energy Efficiency Ratio (EER)		3.64
Annual energy consumption		151.00 kWh/year

Chapter IV. Estimating the value of energy efficiency measures in public buildings

Rules for calculating the construction cost

The construction pricing policy concerns the objective establishment of the estimated value of contracts for the execution of construction-assembly works in accordance with the economic policy and the single pricing policy of the Republic of Moldova, with price ratios reflecting supply and demand on the capital investment market.

The value of the estimate is the initial basis for determining the value of the investment required to achieve the construction objectives, for determining the value of the contractor's contracts, for settling payments for the contractor's work (construction-assembly work), for settling expenses for the purchase of equipment and its transport to the construction site, and for settling other expenses from the funds provided for in the general estimate.

On the basis of the estimated value of the construction target and the value of the contractor contracts, accounting records and reports are drawn up, the work of the contractor organisations and beneficiaries is estimated, and the value of the capital assets of the enterprises, buildings and special constructions built is estimated.

Under market economy conditions, the value of the construction works is determined by the investor (beneficiary) and the contractor during the conclusion and performance of the contract. For this purpose, during the preparation of tenders, the following are established for the formation of the contract value:

a) in the course of preparing the feasibility study and the project and estimate documentation, at the investor's request, investment estimates are prepared (calculation of the approximate value of the construction items and the entire target);

b) in the process of signing the contract, including by tendering on the basis of the documentation received from the investor, the contractor's bid estimate is drawn up.

The investor's and contractor's estimates (calculations) are prepared in accordance with the methods specified in the normative documents on construction pricing, taking into account the construction conditions, contractual relations and economic policy in general.

This is used as a basis for determining the estimated value of the building:

- technical design and execution drawings or the execution project, in which the parameters of buildings and special constructions, their components and elements are defined, including drawings, lists of quantities of construction and assembly works, specifications for equipment, the main solutions for the organisation of the construction, specified in the "Construction organisation" project, as well as explanatory notes on the nominated materials;
- normative documents and costing norms in force, prices for material resources, energy, labour, machinery, furniture, and inventory.

The construction pricing system is a set of pricing rules, which include:

- ✓ The normative documents that contain the regulations and recommendations for the determination of the value of building objectives;

- ✓ Costing rules for construction, assembly, repair, restoration and demolition work, which include consumption rules for labour, operation of construction machinery, and consumption of materials defined per unit of measurement;
- ✓ Estimation rules for overheads, estimation of profit, purchase and storage costs, estimation rules for the construction of buildings and special temporary structures, additional costs of carrying out work in cold weather, maintenance of the beneficiary's services, etc., expressed as a percentage.

In the Republic of Moldova, there are two types of estimation rules in use:

a) Rough estimate norms, such as the Estimate Norms for Construction, Assembly, Repair, Restoration and Adjustment-Demarcation Works, implemented since 1 January 2002. Rough estimate norms are used for the preparation of estimates by investors and can also be used by construction organisations;

b) The costing norms of the enterprise (the normative basis of the user - the enterprise norms), to which the individual costing norms refer and which take into account the actual working conditions of the enterprise performer. This normative basis is usually based on rough estimation rules. The user's normative basis is used to prepare the contractor's estimates (for determining the value of tenders).

Estimated value = Price of construction works + (Price of the assembly work + Price of the equipment) + Overheads + Estimated profit

According to the National Accounting Standards (NAS), construction contracts differ according to the pricing method:

1) Fixed price construction contracts provide for a fixed price for the contract as a whole or a fixed payment per unit of subject matter or work agreed between the beneficiary and the contractor. In some cases, the contract may include clauses to increase the fixed price;

2) Cost-plus construction contracts provide for the beneficiary to recover the negotiated contract costs plus a percentage of those costs or a fixed fee;

3) Mixed construction contracts combining fixed price and cost-plus contract provisions.

Contract income includes: (1) initial income (estimate value); (2) contract modification income; (3) claims income; and (4) incentive income.

Contract costs include (1) direct contract costs, (2) indirect contract costs and (3) construction overheads recoverable from the beneficiary.

Direct contract costs are those costs that can be included directly in the cost of the construction contract. Their composition is given in Annex 2.

Contractual indirect costs include (1) the costs of providing goods and personnel related to multiple contracts, where these are not included in construction overheads; (2) the costs of design and technical assistance related to multiple contracts, where these are not included in construction overheads; (3) the costs of borrowing related to multiple contracts, capitalised in accordance with the NAS "Borrowing Costs"; and (4) the costs of operating machinery and plant used in the execution of multiple contracts during a management period (the composition of which is indicated in Subitem 4 of Annex 2).

Overheads are divided into recoverable and non-recoverable costs. Until allocated, overhead is accounted for separately by the contractor.

Construction overheads recoverable from beneficiaries include:

1) general and administrative costs;

2) costs for servicing construction staff;

3) costs of organisation of work on construction sites;

4) other general costs.

Recoverable overheads are included in the construction contract costs and are taken into account in calculating the proportion of construction overheads to be used in preparing the cost estimates for each contract.

Non-recoverable construction overheads by beneficiaries include

1) costs related to scientific research and development work;

2) taxes and charges prescribed by law;

3) the statutory bonuses paid to the company's employees;

4) costs associated with compensating employees for damages resulting from work-related accidents;

5) payments made to employees made redundant as a result of restructuring, reducing the workforce;

6) other costs.

The overhead costs that are not recoverable from the beneficiaries are allocated directly to the current expenditure.

Rules on estimate norms and unit prices for categories of works

Estimating norms for construction works are primary estimating norms from which unit prices are developed to determine direct estimating costs. Estimation norms are developed for all categories of work.

Normative indicators of resource consumption are defined in the costing norms for a given unit of categories of works:

- workmanship;
- construction equipment requirements;
- consumption of materials, articles, and construction elements (hereinafter - materials).

The resource requirements included in the composition of the estimation norms are determined as follows:

- *for workmanship* - on the basis of the workmanship norms in force for construction works, and for works not included in the norms - by the method of time recording, photographing of working time, etc;

- *for the operation of construction equipment* - based on production standards derived from the performance of the equipment included in the technological file;
- *for materials* - based on general or company material consumption norms, specified in the design drawings or by the calculation method.

Only consumption relating to direct expenditure, including consumption for the transport of materials, items and components from the site store to the place of installation, assembly or erection on site, shall be included in the estimate. Consumption relating to overheads and the contractor profitability shall not be included in the estimate.

Rules for the establishment and application of unit prices for construction works

The basis for setting unit prices is provided by

- Costing rules for all categories of work;
- The value of 1 man-hour of construction labour;
- The value of 1 man-hour of construction equipment, determined according to the type of machinery and equipment used;
- The estimated prices of building materials, items, and elements.

Unit prices may be calculated at the level of direct costs (including labour costs, social and health insurance contributions, machinery operation and value of materials, including transport and purchase and storage costs) or at the level of the contract price (including direct costs, overheads, and limited overheads, estimated profit).

Rules for determining the cost prices by resource type

The *value of 1 man-hour* is determined in accordance with the provisions of the normative document CPC L.01.02:2012 and AMENDMENT CPC L.01.02:2012/A2:2022 Guidelines for Determining the Cost of Construction Labour Cost Estimates.

According to this document, the value of 1 man-hour is determined by the average monthly wage of a construction worker in the enterprise or the wage included in the contract price (agreed with the beneficiary) for the construction of the given object. The determination of the average monthly wage of workers is carried out by profession and category in accordance with the regulations in force.

The 2022 amendment establishes the method for calculating the average hourly wage of construction workers for the procurement of design and construction-assembly works of all categories, related installations and overtime intervention works on existing constructions (modernisation, restoration, alteration, conversion, consolidation, extension and capital repairs) for the needs of one or more contracting entities, irrespective of the source of financing of the investment.

At the request of the investor (beneficiary) in the investor's specifications, labour costs are determined in the project and tender documents and specifications on the basis of the provisions of national legislation:

- Labour Code 154/2003, which regulates work under unfavourable conditions; work on public holidays; the right to leave and remuneration; accepted wage systems.
- The guaranteed minimum wage in the real sector at national level is set by Government Decision No. 165/2010, as subsequently amended, as specified in point 1 of the Decision. Pursuant to

Article 12 of the Wages Act No 847/2002, as subsequently amended, a Government Decision periodically amends point 1 of Government Decision No 165/2010 and establishes, with effect from a certain date, the guaranteed minimum wage in the real sector (in enterprises, organisations, institutions with financial autonomy, irrespective of the type of ownership and the legal form of the organisation), calculated for a full working day averaging 169 hours per month.
- Collective labour agreement (national level) between the Government of the Republic of Moldova, employers and trade unions, approved by Government Decision No. 198/2001 for the purpose of implementing coordinated actions and measures to stabilise the economy, ensure minimum socio-economic guarantees and protect the legitimate rights and interests of workers and employers.

The calculation of the average hourly wage of construction workers for the purpose of determining the value of the contracting authority's estimate and the contract prices of the construction objectives in the public works procurement procedure is presented in Annex 3.

The value of 1 h-m (machine hour) is determined in accordance with CPC L.01.04-2012. According to this document, the value of 1 hour per type of machine is calculated by the contracting companies owning construction equipment by calculating the expenses (for fuel, lubricants, parts, depreciation, mechanics' wages, maintenance and moving of equipment, etc.). Contractors who own construction machinery are recommended to maintain computerised databases of the primary data sheet on the operational value of the machinery.

In the estimate and tender documentation prepared at the investor's request (in the investor's estimates), the value of 1 h-m. per type and group of machinery is determined on the basis of the information available to the preparer on the respective prices. As a rule, the average prices for 1 hour of operation of machines of the respective group are determined in the district, the locality where the construction site is located.

The value of material resources is determined on the basis of information available to the developer on prices for this type of expenditure. In the case of contractors, average data on the actual value of materials, articles and construction elements (taking into account transport costs from the place of purchase to the construction site warehouse, including loading and unloading, and the enterprise's costs for purchase and storage), determined on the basis of market prices, individual tariffs of supplier enterprises and data from the accounts.

*The estimated prices of materials, articles and components (*hereinafter referred to as "materials") include:

- the purchase price, including the price of packaging and intermediaries' commercial mark-ups, payments for commodity exchange services (including brokerage), tariffs, and customs duties;
- the cost of transport and loading and unloading;
- the purchase and storage costs, including the cost of completing materials.

Material cost estimates are used to determine the cost value of construction and assembly work and are applied at current price levels using information from domestic and overseas suppliers and material receivers, as well as information on freight rates.

Material cost estimates include not only the cost of procuring materials but also the cost of pre-purchasing materials.

The cost estimates for materials shall include the value of packaging and supplies, taking into account the repeated use of packaging, containers, pallets, and packages in the transportation of bricks and other materials. The estimates for packaging and supplies shall also include the cost of repairing the packaging, returning containers, pallets, etc. to the supplier and their depreciation, and, where the packaging is sold by the consignee, the return value shall be taken into account. The value of packaging and supplies shall be calculated according to the manufacturer and supplier data.

Transport is calculated and included in the calculations on the basis of actual or average data for the unit of measurement adopted for the material transported (in m^3, t, m^2, etc.) or in percentages of the value of the material per 1 t-km of load. The transport of materials from the site depot to the working face is included in the cost estimate norms and in the unit prices for construction-assembly works. The cost of transporting materials is determined at current prices for different categories of transport (road, rail, inland waterway, tractor, etc.).

Purchasing and storage costs are intended to cover the costs incurred by contractors in maintaining purchasing and storage services (supply departments, production engineering departments), central material stores and the natural perishability of materials during transport and storage. Purchasing and storage costs are calculated as a percentage of the cost of materials, excluding transport costs and VAT, and are included in the calculation of the estimate for the construction and installation work. Each contractor calculates and approves individual rates for purchasing and storage costs using data from the accounts. The rates can be reviewed and re-approved as necessary (usually once a year).

In the tender and offer documentation prepared at the investor's request (investor's offers), the value of material resources is determined on the basis of market prices for materials, articles, and construction elements, average freight rates, and purchase and storage costs. The rates for purchase and storage costs are calculated as a percentage of the value of the material (equipment), using the following average norms by branch:

a) for building, technical, sanitary and electrotechnical materials - 2 per cent;
b) for equipment - 1.2 per cent;
c) for metal construction - 0.75 per cent.

Rules on estimate norms and unit prices for the assembly of equipment and rules for determining the value of equipment

Estimation norms for the installation of equipment are intended to determine the value of the estimate for the installation of technological equipment.

The following should be taken into account when working out the norms of equipment assembly costing:

- Rules and instructions for the organisation, execution, and acceptance of the installation of equipment, as well as branch and plant instructions for the installation of equipment;
- Standards, technical specifications and other normative documents determining the conditions of equipment delivery;
- Technological data sheets and work execution projects for the assembly of heavy equipment and unique heavy equipment, as well as standard technical solutions for the assembly of other categories of equipment;
- The norms for the execution of construction works;
- Normative indicators of material consumption.
- The unit prices for the installation of equipment are determined on the basis of the estimate norms and the prices of resources included in the estimate norms. The following must be included in the calculation of the unit price for the installation of equipment.
- The value of 1 man-hour of labour;
- Electricity and heating costs;
- Prices for the operation of construction equipment;
- Prices of materials.

The norms and unit prices shall stipulate that the assembly equipment is supplied complete and painted:

- ✓ normal gauge - in assembled condition with protective cover and on permanent linings;
- ✓ oversized - in disassembled state or in blocks that do not require adjustment, running-in, tests according to the technical conditions of execution and delivery, with static and dynamic balancing of the rotating parts.

The following work must be included in the norms and unit prices:

- Reception of equipment for installation;
- Horizontal and vertical movement of equipment, including loading and unloading;
- Unpacking of equipment and removal of packaging;
- Cleaning of grease and coating of equipment;
- Technical inspection of the equipment;
- Grouping of equipment delivered in separate parts or sub-assemblies for assembly into maximum grouped blocks within the lifting capacity of the assembly equipment and rigging means;
- Receiving and checking foundations and other equipment supports, marking out the equipment installation site, installing anchor bolts and embedding parts in foundation shafts;
- Preparing equipment and rigging for operation;
- Installing equipment, checking and fixing it to foundations or other supports, including the installation of mechanisms, devices, equipment forming part of the equipment or the delivery set,

fans, pumps, drives, regulating and control devices, capacities, metal structures, piping, etc., as specified in the technical drawings of the equipment;

- Welding, including preparation of edges for welding;
- Filling lubricants and other materials into equipment;
- Checking the quality of erection, including individual equipment tests.

Should not be included in norms and unit prices:

- ✓ Construction work related to the installation of equipment (pouring the levelling layer for foundation slabs, filling bolts and parts embedded in the foundation, lining equipment, building stoves and fireplaces, etc.);
- ✓ Work related to the cost of equipment (overhaul and finishing of equipment before assembly);
- ✓ Transport of equipment to the site depot;
- ✓ Adjustment work and complex tests.

Rules for determining the value of equipment

When drawing up the local cost estimate, the value of the equipment shall be included in the separate cost estimate. The value of the equipment estimate is determined as the sum of the costs of purchasing and transporting the equipment to the annexed warehouse or to the place of delivery for assembly. The estimated value of the equipment consists of

- The purchase price of the equipment;
- The value of spare parts;
- The value of packaging;
- The cost of transport and intermediate services or supplies
- Completion costs;
- Storage and warehousing costs;
- Other expenses relating to the value of the equipment.

Of the expenses listed, only those not included in the purchase price are taken into account and must be offset.

Rules on overheads and construction investor benefit

Overheads are a component of the cost price of the contractor's works and represent the total consumption related to the creation of conditions for the execution of the works, their organisation, management and maintenance.

The structure of the chapters and the application of the norms for construction overheads are defined in the National Accounting Standard "Construction Contracts".

Contrary to direct consumption, overheads are determined indirectly as a percentage of the accepted basis of calculation and can therefore be used:

a) the amount of direct expenditure of the estimate determined at current prices (direct expenditure - expenditure on the wages of construction workers, including social security and health insurance contributions, expenditure on the operation of machinery and the purchase of building materials, including transport and purchase and storage costs);

b) expenditures on wages and salaries of workers (fitters) in direct expenditure.

In the investor's estimates, the standard overheads are determined according to their average size in the construction industry. The data on the average share of overhead in each industry is periodically disseminated by the NBMA through a regulatory letter published in the Official Gazette.

The structure of consumption and the method of calculating overheads are specified in the normative document CPC L.01.03-2012.

The estimated profit is the sum of the funds necessary to cover the contractor's overhead, which are not included in the cost price of the works and are a standard (guaranteed) part of the value of the construction work.

The contractor profitability is intended for payment of taxes and development of production, including modernisation of equipment, reconstruction of fixed assets, payment of interest on bank loans, partial replenishment of own working capital, etc. (Annex 4). The structure of the expenditure items included in the contractor profitability account and the method of determining the amount of the contractor profitability are specified in the normative document CPC L.01.05-2012.

The standard (quoted) contractor profitability is calculated in percentages as the ratio of the amount of the contractor profitability, determined in accordance with the established list of expenditure items, to the estimated cost price of the work performed.

The individual rates of contractor profitability shall be calculated or specified by the contractor and approved by management.

When determining the value of the construction production estimate (when preparing the investor's estimate), the value of the contractor profitability is determined on the basis of the average rate per branch. The data on the average rate per branch of the contractor profitability is periodically disseminated by the NBMA by means of a regulatory letter published in the Official Gazette.

The contractor profitability is determined as a percentage of the estimated cost price, which is determined by adding direct costs and overheads.

Rules for other expenditure to be included in the estimate of building costs

Expenditure forming part of other expenditure is a component of the estimated value of the construction, is listed separately in the cost estimate documentation and may relate either to the construction (objective) in general or to separate works or items.

With regard to energy efficiency measures in public buildings, we will only draw attention to the following categories of expenditure:

- for the reimbursement of other expenses related to the contractor's activity, in the cases provided for by law: additional expenses for the transport of workers, the mobile or itinerant nature of the work, travel expenses and the method of exchange, etc. In the investor's estimates, these expenses are included in the amount of 0.9 per cent (average value per branch) of the construction-assembly work;

- to cover other expenses related to the activity of the beneficiary:
  - "Maintenance of the management (technical supervision) of enterprises (institutions) under construction" includes means for the maintenance of the beneficiary's services, by applying the expenditure limits established in accordance with Annex C to CPC L.01.01-2012 or determined in accordance with CPC L.01.08-2012 "Instructions for determining expenditure for the maintenance of the beneficiary's service".
  - "Design work, surveys, author control" includes the means for:
    - Execution of research and prospecting works - separately for research and prospecting works - energy audit;
    - Execution of the author's control of the construction works by the design organisation;
    - Verification/evaluation of the feasibility study, project documentation, and cost estimate;
    - Execution of paid approvals, obtaining technical regulations and permits;
    - Payment for obtaining the town planning certificate and its extension, for the building permit or for the demolition of the object;
    - Organising tenders for the design and execution of works.

The nominated works and expenses shall be determined in accordance with the provisions of the CPC L.01.01-2012 and other regulations in force at the time of preparation of the tender documentation.

Recommendations for drawing up the estimates for public works contracts

The information given in Table 24 is to be used in determining the estimated value of construction targets financed from the national public budget:

- when investors or design organisations prepare estimates of the value of construction targets;
- when contractors prepare contract value and tender estimates for construction works.

Table 24. Normalised expenditure rates

Category of expenditure	Rates
Overheads:	
from direct expenditure	14.5%
from the wages of construction workers (for the assembly of equipment, electrical installations, etc.)	76.0%
from the wages of the adjustment and maintenance staff	60.0%
Contractor profitability	6.0%
Expenditure on the transport of materials (from the cost of procuring materials, excluding VAT):	
for construction objectives, located in municipality Chisinau	7.0%
for construction objectives, located in the municipality Balti	8.0%
for construction sites located in other localities.	10.0%
for natural gas supply networks and related installations	2.0%

for networks (as linear objectives) of natural gas supply, water supply, sewerage, and related facilities	4.0%
for roads, man-made structures, and civil engineering works	According to actual data according to price catalogue No. 13-01-09, taking into account the conversion factors to current prices reflecting actual expenditure.
Average hourly wage of construction workers:	According to the amendment of the CPC L.01.02:2012/A2:2022 *Instructions for the determination of the cost estimate for construction wages* in 2022, the average wage of a construction worker per branch is 53.95 lei/hour.

When drawing up tender estimates for public works contracts financed from the public budget, the tenderers shall take into account bonuses, supplements, allowances, incentive payments and compensations, if they are stipulated in the individual employment contract or collective labour agreement, when determining the average wage of the employees, in accordance with the methodology for drawing up tender dossiers, as required by CPC L.01.01 and the provisions of B.2 of the Instructions for the AMENDMENT CPC L.01.02:2012/A2:2022, but not less than the fixed and published average wage quarterly by the NBS (National Bureau of Statistics).

In accordance with the provisions of Government Resolution No. 638 of 26.08. 2020 on the approval of the Regulation on Public Works Procurement, in the process of examining, evaluating and comparing tenders, the working group of specialists of the contracting entity carrying out public procurement procedures shall, in the case of a tender whose value is less than 85 per cent of the estimated value of the works, verify the calculation of the elements of the price and the compliance of the tenderer with the technical requirements set out in the specifications, check the calculation of the price components and the compliance of the tenderer with the technical requirements set out in the contract documents, request the written justification of the apparently abnormally low price before taking a decision to reject this tender, request details and clarifications which it considers relevant to the tender, and check the answers justifying this price.

The working group has the right to correct any arithmetical errors found during its examination of the financial offer or the tender estimate and to notify the bidder immediately. If the bidder does not accept the correction of such errors, his bid will be considered inadequate and rejected.

If the tenderer submits abnormally low values for overheads (calculated in accordance with CPC L.01.03), contractor profitability (calculated in accordance with CPC L.01.05) or material costs, the contracting authority is entitled to request supporting documents, e.g. the previous year's financial report, in order to verify the values stated in the tender.

Construction cost index of energy efficiency measures

Rules on combined estimate norms

Composite estimation norms and value indicators for construction of buildings and execution of certain categories of works (hereinafter - composite estimation norms and indicators) are intended to determine in a simple and accessible way the value of objects and works derived from construction and other parameters of buildings and special constructions or from composite units of work volumes.

Composite estimation norms and value indicators are divided into

- Indicators for Categories of Works (ICW);
- Composite Value Indicators for the Construction of buildings and special constructions (CVIC);
- Composite Resource Norms (CRNs);
- Composite Resource Indicators (CRI).

Composite estimation norms apply to the elaboration of project documentation at the "technical design" and "feasibility study" stages.

Composite estimation norms and value indicators are used to determine the value of the objectives and work in the initial stages of elaboration of feasibility studies to justify the estimated value of investment objectives.

ICW is developed for construction and assembly works on the basis of building design model solutions and repeated use of individual economic projects. ICWs are prepared for separate construction elements for categories of work and equipment of the object. ICWs contain their composition indicators of consumption elements in the value and resource structure.

In the process of ICW application, the data on the tracking and price recording of the resources used are used, and the climatic conditions in the construction area and the production peculiarities of the contractors are taken into account.

For the planning of energy efficiency works/measures in public buildings, the construction cost index is calculated by work categories.

The ICW for construction includes the following categories of expenditure:

- Value of materials, including transport and purchase and storage costs;
- Wages, including social and medical insurance;
- Operation of equipment.

ICW for construction works for energy efficiency of buildings

In order to improve the energy efficiency of public buildings, value indicators have been developed for specific categories of works. ICWs correspond to the technological solutions described in the previous chapter and can be applied to any category of public buildings (schools, kindergartens, hospitals, administrative buildings, etc.).

Value solutions in the "economic" and "medium" categories are proposed to ensure the minimum energy performance of buildings.

The value indicators are developed in Q2 2023 prices.

Table 25. ICW for energy efficiency works in public buildings

<table>
<tr><th>Insulation</th><th colspan="3">The technological solution</th></tr>
<tr><td rowspan="3">Basement / semi-basement thermal insulation</td><td>Insulation of the semi-basement with extruded polystyrene, 8 cm thick (work on the outside of the building)</td><td>Insulation of the basement with extruded polystyrene, 8 cm thick (work inside the building)</td><td>Insulation of the basement with mineral wool with hydrophobic coating, 10 cm thick (work inside the building)</td></tr>
<tr><td>ICW = 755 lei/m²</td><td>ICW = 746 lei/m²</td><td>ICW = 389 lei/m²</td></tr>
<tr><td>• cleaning the outer surface of the plinth
• priming, deep penetration primer
• plastering (thickness 2 cm) of about 10% for surface repair
• gluing of insulating material
• priming - primer with quartz sand
• decorative plastering (2-3 mm)</td><td>• gluing insulation material to the basement ceiling
• reinforcement
• plastering</td><td>• fixing insulation material to the basement ceiling</td></tr>
<tr><td rowspan="3">Thermal insulation of walls</td><td>Insulation of walls with mineral wool, 10 cm thick</td><td>Insulation of walls with mineral wool, 8 cm thick</td><td>Insulation of walls with expanded polystyrene, 8 cm thick</td></tr>
<tr><td>ICW = 997 lei/m²</td><td>ICW = 974 lei/m²</td><td>ICW = 738 lei/m²</td></tr>
<tr><td colspan="3">• surface cleaning
• repair around door and window frames and sills
• plastering about 10% of wall surface repair (2 cm thick)
• priming, deep penetrating primer
• gluing of wall insulation material
• gluing of thermal insulation material for window and door glazing (outside)
• levelling plaster layer on window and door frames (outside)
• levelling plaster on walls
• priming - quartz sand primer
• decorative plastering walls (2-3 mm)
• decorative plastering of the window and door frames (outside)</td></tr>
<tr><td rowspan="3">Thermal insulation of the roof</td><td>Insulation of the attic floor with mineral wool, 10 cm thick (pitched roof)</td><td>Insulation of attic floor with mineral wool, 15 cm thick (pitched roof)</td><td>Insulation of flat roof with extruded polystyrene, 15 cm thick</td></tr>
<tr><td>ICW = 339 lei/m²</td><td>ICW = 423 lei/m²</td><td>ICW = 890 lei/m²</td></tr>
<tr><td>• anti-vapour film
• laying of thermal insulation material (mineral wool 10 cm)
• anti-condensation film
• construction of access ways (decks)</td><td>• anti-vapour film
• laying of thermal insulation material (mineral wool 15 cm)
• anti-condensation film
• construction of access ways (decks)</td><td>• anti-vapour film
• laying of thermal insulation material (extruded polystyrene XPS 15 cm)
• anti-condensation film
• mortar 4 cm
• 2-layer bituminous membrane</td></tr>
<tr><td>Replacing windows and doors</td><td>Replacement of windows with double-glazed PVC package, replacement of doors (metal doors)</td><td>Replacement of windows with triple-glazed PVC pack, replacement of doors (metal doors)</td><td>Replacement windows with double-glazed aluminium package,</td></tr>
</table>

<table>
<tr><td rowspan="3"></td><td></td><td></td><td>replacement doors (metal doors)</td></tr>
<tr><td>ICW = 3,174 lei/m² voids</td><td>ICW = 3,673 lei/m² voids</td><td>ICW = 4,590 lei/m² voids</td></tr>
<tr><td colspan="3">• dismantling windows
• dismantling of exterior doors
• installing windows
• mounting of inner and outer sills
• installing door
• priming (on the inside)
• plastering (inside)
• priming (inside)
• painting (inside)</td></tr>
<tr><td rowspan="3">Assembly work (only manpower)</td><td colspan="2">Indoor electric lighting</td><td>Outdoor electric lighting</td></tr>
<tr><td colspan="2">ICW = 37 lei/unit (node/position)</td><td>ICW = 134 lei/unit</td></tr>
<tr><td colspan="2">• dismantling light bulbs
• fitting the LED bulbs</td><td>• dismantling the outdoor light
• fitting the outdoor LED</td></tr>
</table>

Determination of the value of the energy efficiency measure

The value of the investment target for the energy efficiency of public buildings will be determined according to the planned measures and the calculation algorithm provided by the Building Code of the Republic of Moldova.

The value of the construction works is determined by multiplying the ICW of the chosen solution by the corresponding area of the building. The algorithm shown in Table 26 is used to estimate the value of the project. Examples are given in Annex 6.

Table 26. Estimating the value of the building energy efficiency project

Nr.	Theme	Name of expenditure	Calculation formula	Amount, lei
1	Chapter 1. Construction works			
1.1		Basement / basement thermal insulation		
1.2		Thermal insulation of walls		
1.3		Thermal insulation of the roof		
1.4		Replacing windows and doors		
1.5		Total	r.1.1+1.2+1.3+1.4	
1.6		Overheads	14.5% of 1.5.	
1.7		Total	r.1.5+r.1.6	
1.8		Contractor profitability	6% of 1.7	
1.9		**Total Chapter 1**	r.1.7+r.1.8	
2	Chapter 2. Assembly work			
2.1		Indoor electric lighting		
2.2		Outdoor electric lighting		

2.3	Contract	Value of equipment[33] (including assembly work and adjustment work on equipment; excluding of VAT)		
2.4		Total	r.2.1+r.2.2	
2.5		Overheads	76% of r.2.4	
2.6		Total	r.2.4+r.2.5	
2.7		Contractor profitability	6% of 2.6	
2.8		**Total Chapter 2**	r.2.6+r.2.7+r.2.3	
2.9		**Total Chapter 1 and 2**	r.1.9 + r.2.8	
3	Chapter 3. Other expenditure			
3.1	CPC L.01.01-2012 p.6.6	Additional costs for transport, travel etc.	0,9% of r.2.9	
3.2	CPC L.01.01-2012 Annex C	Technical surveillance	According to Annex 5. in % of r.2.9	
3.3		**Total Chapter 3**	r.3.1+r.3.2.	
4	Chapter 4. Design work, surveys, author control			
4.1	Contract	Design works		
4.2	CPC L.01.01-2012, pct.6.10.2	Execution of author's control of the construction object by design organisations	0,3% of r.2.9	
4.3	CPC L.01.01-2012, pct.6.10.3	Review of feasibility documentation, project documentation and cost estimates	According to current tariffs	
4.4		**Total Chapter 4**	r.4.1+r.4.2+r.4.3	
5		**Total Chapter 1-4**	r.2.9+r.3.3+4.4	
6	CPC L.01.01-2012, pct. 6.11	Reserve for unexpected expenditures	2% of r.5	
7		Total	r.5 + r.6	
8	CPC L.01.01.2012 pct. 6.14	VAT	20% of r.7	
9		**TOTAL PROJECT**	r.7 + r.8	

[33] The seller only provides a guarantee if the assembly and testing of the equipment is included in the contract (price) or is carried out by a company officially recognised by the seller.

Chapter V. Efficient investment in energy efficiency measures in public buildings

The economic effectiveness of energy efficiency measures

Starting from the linguistic meaning of efficiency (to produce the expected useful effect), it can be said that efficiency is the attribute of any human action to produce the desired useful effect. Effect is the result of something and can be positive, negative or zero.

The ways and forms in which efficiency materialises in the productive sphere are:

a. reduction in consumption of raw materials, materials and energy resources (fuel, electricity, heat, etc.);
b. reducing transport costs;
c. increasing labour productivity;
d. increasing business profitability;
e. improving the quality of products/works, etc.

Economic efficiency is a complex concept that reflects in the most comprehensive way the results obtained in an economic activity, evaluated in relation to the resources used to carry out that activity. Economic efficiency is the link between the quantity and quality of effort, as effect-producing factors, and the results obtained in a given period as a consequence of that effort.

Efficiency can have two meanings:

1. The maximum impact of an activity in relation to the resources allocated or consumed.
2. Creating the same effect with less effort.

As a result of the investment effort (I), various economic effects (E) are achieved, which are also reflected in financial terms. The level of these effects, relative to the investment effort, provides a measure of the efficiency of the investment:

$$e = E / I \rightarrow \text{max.}, \quad (5.1)$$

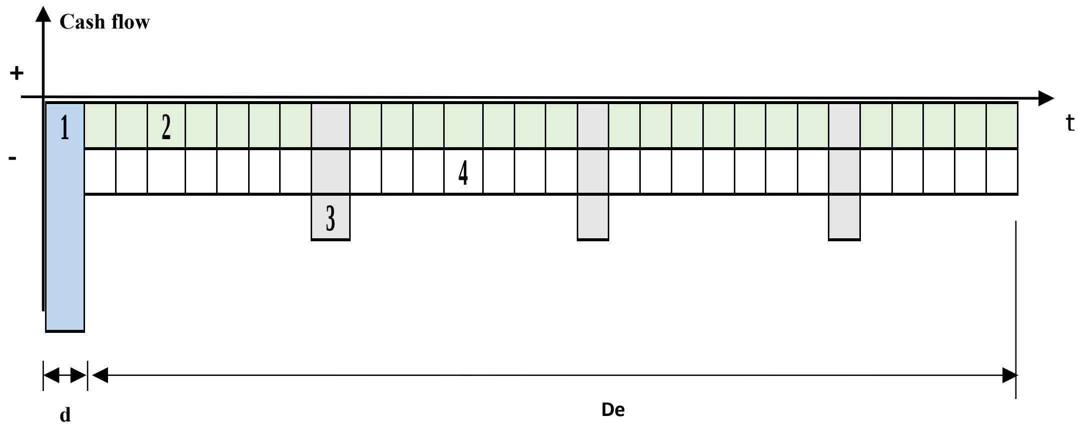
In terms of investments to ensure the energy performance of public buildings, the economic impact can be significant.

- Reduce heat loss within the building;
- Reducing fuel consumption;
- Reduction in energy consumption (electricity, heating);
- Reduced running costs of equipment (maintenance, repairs) as a result of replacement investment.

The following works/activities/measures related to public buildings are intended to achieve the same effects (year-round thermal comfort, sufficient lighting) at lower costs, i.e. to ensure the economic efficiency of energy performance activities (Figure 15).

Since public buildings do not participate in the process of production or create material value, they do not generate income, and any investment expenditure is justified only if it leads to a reduction in operating costs over the economic life of the building.

There are different methods of assessing economic efficiency. In this paper we will focus on the recommendations of the European standards accepted as national standards in the Republic of Moldova, in particular the standard SM EN 15459-1:2017 Energy performance of buildings. Methods for the economic evaluation of energy systems in buildings - Part 1: Calculation Methods, Module M1-14 proposes the economic evaluation of energy systems using the "total cost" method, defined as "the sum of the present value of the initial investment costs, annual operating costs and replacement costs (reported to the starting year), as well as disposal costs, if any".



Legend
t - the period under consideration for calculation (e.g. 30 years)
d –the implementation period, during which the investments are recovered
De –the period of economic use of the building
1 – initial investment effort - **I**
2 – costs during the period of exploitation of the building (operation of equipment) - **CS**
3 –replacement (investment) costs - **CÎ**
4 –economic advantage, reduced costs following implementation of energy efficiency measures - **E**

Figure 16. Overview of the economic effects of energy efficiency measures in public buildings

The standard recommends the use of all or part of the method for the following applications

- Evaluation of the economic feasibility of energy saving options in buildings;
- Comparison of different solutions for energy saving options in buildings (energy sources, fuels, ...);
- Evaluation of the economic performance of an overall building design (e.g. trade-off between energy demand and energy efficiency of heating systems);
- Evaluation of the impact of possible energy saving measures on an existing heating system by economic calculation of the cost of energy consumption with and without energy saving measures.

According to the requirements of SM EN 15459-1:2017 and the clarifications of SM CEN/TR 15459-2:2017, the economic effectiveness of energy efficiency measures should be evaluated using **the investment payback period** indicator.

The project is considered acceptable if:

1. Its total cost is lower than other project options (solutions);

2. Its total cost is lower than the total cost of the reference over the same period. For existing buildings, the reference could be the current state (nothing is done);
3. The payback period is shorter than the lifetime of the options under consideration.

The concept described in SM EN 15459-1:2017 combines investment evaluation indicators/methods known in the literature as

- the commitment capital - K;
- payback period - T;
- net present value - NPV.

The ***commitment capital*** expresses the total initial investment cost of the planned works (construction, erection, installation, etc.) and the post-commissioning costs of their operation, excluding depreciation, expressed in present value terms at a reference date.

The time horizon for the calculation of capital employed is (*d+De*) or a conventional calculation period. When comparing projects with different economic lifetimes, new alternative decisions are considered for the time interval given by the difference in *De*, with the lower *De* variant equivalent to the level of the higher *De* variant. The commitment capital is determined using this equation:

$$K_t^{/} = I_t^{/} + CE_t^{/} = \sum_{h=1}^{d+De} (I_h + CE_h)(1+a)^{-h} \qquad (5.2)$$

The project is acceptable if the discounted committed capital is less than the total discounted positive cash flow (CF'). The CF represents the annual savings, i.e. the difference between the operating costs of the building without the energy efficiency measure and with the measure.

The indicator allows the analysis of savings on investments such as technology and performance technologies. For energy efficiency projects in public buildings, the Total Discounted Cash Flow is the sum of annual savings and depreciation.

As this indicator responds to the concern to achieve the desired objectives with minimal effort, it is recommended to be used as a criterion for the selection of investment projects in areas of public interest financed from the budget.

Calculation and analysis of this indicator are provided by the methodology of international financial and banking organisations, known as Total Discounted Cost (TDC).

An alternative to the commitment capital (K', TDC) is the total cost (TC) indicator developed by the W55 Working Committee on Construction Economics of the International Council on Construction (ICC) of the United Nations and recommended for the evaluation of building and special construction projects, i.e., for the selection of their design alternatives according to the cost criterion.

The "***total cost***" indicator expresses the present value of the costs of (1) initial investment, (2) subsequent building operation and maintenance (interventions, ongoing repairs), replacement of equipment, and (3) disposal (final) costs over the economic life of the investment project or over a conventional period.

The projects to be compared must provide the same level of performance in terms of quality, comfort, operational safety, environmental protection, etc.

In the economic analysis of projects, the absolute level of the K', TDC and TC indicators is used to determine whether a project is acceptable or not, to determine the size of investment funds, to choose a planned variant and to set priorities when the budget of the economic agent is limited.

The ***payback period of investments*** is the period of time, starting from the commissioning of machinery, equipment, etc., during which the cumulative number of economic benefits obtained is equal to the volume of investments foreseen in the projects.

This indicator allows us to know how long it will take for the investment costs to be recouped through the economic benefits generated after the project has been implemented, while the decision is still being prepared. This indicator was the first formalised criterion used to evaluate investment projects. Both in theory and in practice, the payback period of investments is calculated using a static and a dynamic approach to economic processes.

In the static approach, the payback period is determined by the equation:

$$T = \frac{I}{\overline{\overline{E}}}, \qquad (5.3)$$

Where: I - investment effort; E - economic benefit in annual average. For energy efficiency projects in public buildings, the cash flow indicator CF - the flow of annual savings accumulated as a result of the implementation of the measures - serves as the economic benefit.

The investment project is acceptable if both conditions are met:

$$De > T < (Ts; Tmax), \qquad (5.4)$$

On the one hand, the payback period must be less than the economic lifetime of the building, and on the other hand, T must be less than or equal to the predetermined value (e.g. at sector level or maximum acceptable). Naturally, priority is given to the project with the fastest payback.

In the dynamic approach to investment projects, the payback period is determined on the basis of equality:

$$\sum_{h=1}^{T'} E'_h = \sum_{h=1}^{d} I'_h , \qquad (5.5)$$

in which:

T' - dynamic payback period;

E'_h, I'_h - discounted values of annual economic benefits and annual investment tranches.

The payback period, in both the static and dynamic approaches, does not take into account the magnitude of the effective life (De) and is poorly sensitive to variations in De across variants. T and T' do not tell us what volume of economic benefits can be obtained after T or T' years until the end of the lifetime De.

Net present value is a key indicator for the economic and financial evaluation of any investment project. NPV characterises, in absolute value, the contribution of the economic benefit of a given investment project, the gain, reward or return to the investor for the capital invested in that project, expressed either as cash flow in present value or as net present value.

Referring to investment projects to ensure the energy performance of public buildings, since the economic benefit is expressed by the flow of savings, the NPV indicator is often also referred to as adjusted net savings.

The NPV indicator compares the total discounted cash flow generated over the economic life of a project or investment project variant (CF) with the total investment effort generated by that project, also expressed in present value (I). The reference moment for calculating the present value of the investment and the cash flow is the moment when work starts.

If the implementation period of the investment project d is short, less than 1 year, and the use of facilities, equipment and service capacities starts immediately, in the same year:

$$NPV = -I + \sum_{h=0}^{De} \frac{CF_h}{(1+a)^h}, \qquad h = 0, 1, 2..., De, \tag{5.6}$$

If the project duration is more than 1 year, d > 1 year:

$$NPV = -\sum_{h=0}^{d} \frac{I_h}{(1+a)^h} + \sum_{h=d}^{De} \frac{CF_h}{(1+a)^h}_h \tag{5.7}$$

On the other hand, this indicator can be expressed as the algebraic sum of the annual net value over the time horizon (d+De).

The annual net value (NV), for each year h, is the difference between the annual volume of projected revenues (savings) from an investment project, V_h, and the volume of total annual investments and costs in service in year h, (I+CS=K):

$$NV_h = V_h - (I_h + CE_h) = V_h - K_h\ , \tag{5.8}$$

So:

$$NPV = \sum_{h=0}^{d+De} NPV_h = \sum_{h=0}^{d+De} \frac{NV_h}{(1+a)^h}, \tag{5.9}$$

As a general rule, projects or project variants with an NPV > 0 are acceptable. In economic and financial terms, an investment project with a positive NPV means that the project is economically viable:

- has the capacity to repay the capital invested over its economic lifetime;
- has a total return on initial capital at least equal to the discount rate (a) used in the calculations;
- has the ability to generate excess cash flow and ensure a certain level of net value.

As an exception, a project option for which NPV = 0 is acceptable. In particular, this rule concerns projects aimed at ensuring social impacts, projects paid for by budgetary sources.

With higher NPV, higher profitability is achieved. If NPV is negative, the project is unacceptable, as the return is lower than the discount rate (e < a); the capital in question could be reinvested with a return equal to the discount rate and would bring correspondingly higher benefits.

Thus, the discount rate (a) used in NPV calculations acts as a criterion for testing the efficiency (profitability) of an investment project and for accepting or rejecting it.

The NPV may be negative if the discount rate used in the calculations is too high. The most efficient investment project is the one for which the surplus between CF' and I' is maximum.

The size of NPV depends on the size of the discount rate (a) used in the calculations, which raises the issue of paying particular attention to the informed choice of the discount rate.

Sources of information for the economic evaluation of investment projects aimed at ensuring the energy performance of public buildings are the possible energy efficiency solutions of the building, the building plan, the investment calculation according to the algorithm described in Table 25 and the recommended values in Annex 7.

Updating of investments using the indexation method (or indexation method)

The previous chapter explains how to estimate the investment costs needed to implement specific energy efficiency measures in public buildings (Table 26). However, the value of construction works changes over time. To apply the algorithm at any point in time, it is sufficient to adjust the normative values according to changes in building codes.

The direct costs (ICW) shown in Table 25 are estimated on the basis of current prices in the second quarter of 2023. In order to update them, we propose to apply the indexation (or indexation) method by taking the following steps:

1. Breakdown of direct costs of concrete works by structural elements (labour, materials, operation of machinery and equipment) on the basis of the data in Table 27.
2. Correction of the values obtained with the corresponding index estimated by the National Statistical Bureau of the Republic of Moldova (or calculated according to NBS data).
   Manpower (correction index = Monthly gross average earnings at valuation date / Monthly gross average earnings QII 2023) https://statbank.statistica.md/PxWeb/pxweb/ro/30%20Statistica%20sociala/30%20Statistica%20sociala__03%20FM__SAL010__serii%20lunare/SAL014900.px/table/tableViewLayout1/?rxid=b2ff27d7-0b96-43c9-934b-42e1a2a9a774
   Materials https://statistica.gov.md/ro/evolutia-preturilor-de-consum-in-republica-moldova-in-luna-iunie-2023-9485_60479.html or https://statbank.statistica.md/PxWeb/pxweb/ro/40%20Statistica%20economica/40%20Statistica%20economica__05%20PRE__PRE010__serii%20lunare/PRE012900.px/table/tableViewLayout1/?rxid=8e69070f-3ac5-4b22-ab66-eab8ee8cc25a
   Machinery and equipment https://statbank.statistica.md/PxWeb/pxweb/ro/40%20Statistica%20economica/40%20Statistica%20economica__05%20PRE__PRE040/PRE040200.px/table/tableViewLayout1/?rxid=8e69070f-3ac5-4b22-ab66-eab8ee8cc25a

3. Adding the present values of the components and determining the discounted ICW to be included in Table 26.

Table 27. Structure of direct costs ICW of energy efficiency works

The technological solution	Manpower	Materials	Machinery and equipment
Thermal insulation of basement/semi-basement			
Insulation of the semi-basement with extruded polystyrene, 8 cm thick *(work on the outside of the building)*	*50.46%*	*49.47%*	*0.07%*
Insulation of the basement with extruded polystyrene, 8 cm thick *(work inside the building)*	*57.08%*	*42.88%*	*0.04%*
Insulation of the basement with mineral wool with hydrophobic coating, 10 cm thick *(work inside the building)*	*20.29%*	*79.71%*	*0.00%*
Thermal insulation of walls			
Insulation of walls with mineral wool, 10 cm thick	*49.14%*	*50.68%*	*0.18%*
Insulation of walls with mineral wool, 8 cm thick	*50.28%*	*49.54%*	*0.18%*
Insulation of walls with expanded polystyrene, 8 cm thick	*57.88%*	*41.89%*	*0.23%*
Roof thermal insulation			
Insulation of the attic floor with mineral wool, 10 cm thick *(pitched roof)*	*19.87%*	*80.01%*	*0.12%*
Insulation of attic floor with mineral wool, 15 cm thick *(pitched roof)*	*15.92%*	*83.98%*	*0.09%*
Insulation of flat roof with extruded polystyrene, 15 cm thick	*25.69%*	*73.82%*	*0.49%*
Replacement of windows and doors			
Replacement of windows with double-glazed PVC package, replacement of doors (metal doors)	*6.82%*	*93.11%*	*0.07%*
Replacement of windows with triple-glazed PVC pack, replacement of doors (metal doors)	*5.89%*	*94.05%*	*0.06%*
Replacement windows with double-glazed aluminium package, replacement doors (metal doors)	*4.71%*	*95.24%*	*0.05%*

For example, the ICW for insulating the semi-basement with extruded polystyrene, 8 cm thick, in Q2 2023 is 755 Lei/m^2. To determine the ICW for another date, we follow the steps mentioned in the model in Table 28.

Table 28. Example of updating direct costs

Period	ICW	Manpower	Materials	Machinery and equipment
Q II 2023	100%	50.46%	49.47%	0.07%
	755 lei/m^2	380,99	373.50	0.51
Suppose price index according to NBS		1.05	1.15	1.06
Evaluation date	**830.11 lei/m^2**	400.04	429.53	0.54

Chapter VI. Maintaining the energy performance of public buildings

Regulatory and legislative requirements

Building regulations[34] prohibit the reduction of the thermal performance of the building envelope elements during the life cycle of the building by the building owner or with his consent by replacing the building envelope elements with other elements with lower thermal performance.

The performance of heating and domestic hot water installations in buildings constructed in accordance with the minimum energy performance requirements shall also not be reduced during the life cycle of the building by replacing the components of the heating and domestic hot water installation with other components of lower energy performance.

Heating and hot water installations, as well as building control and automation systems, need to be efficiently operated and managed to maintain initial performance throughout the life cycle of the installations.

The project documentation for the construction of new buildings, new units of existing buildings and major renovations of existing buildings shall include relevant provisions on the requirements for the maintenance of technical installations in order to ensure the maintenance of their energy performance.

Heating and air conditioning systems in buildings and building units must be inspected regularly.

Accessible parts of ventilation, air-conditioning and heating systems or their combined systems with an effective rated output exceeding 70 kW shall be subject to periodic inspection[35].

The periodic inspection shall include an assessment of the efficiency and sizing of the systems concerning the heating and/or cooling requirements of the building and, where appropriate, an assessment of the ability of the system to optimise its performance under typical or average operating conditions.

Non-residential buildings with ventilation and air-conditioning systems and/or heating systems or combined systems with an effective rated output greater than 290 kW should be equipped with automation and control systems where technically and economically feasible.

The energy performance certification of buildings, the inspection of heating systems and the inspection of ventilation and air-conditioning systems shall be carried out by energy assessors, heating system inspectors and ventilation and air-conditioning system inspectors who are qualified and registered by the supporting public institution in the relevant electronic registers.

The frequency and method of periodic inspection of heating systems shall be determined by the Government according to the category of the building, the type and effective rated output of the heating system and other conditions, taking into account the cost of the inspection and the estimated energy savings that could result from the inspection.

[34] NCM M.01.02:2016

[35] Law No 128 of 11.07.2014 on energy performance of buildings.

The date after which the first inspection of the heating system must be carried out is set by the government and depends on the date of installation and commissioning of the system and the frequency of inspections set for this type of system.

Management and proper functioning and maintenance of the objects after the implementation of energy efficiency measures and installation of renewable energy equipment

Management and proper functioning, as well as maintenance of the objects after the implementation of energy efficiency measures and installation of renewable energy equipment, are essential to ensure the long-term effectiveness and benefits of these measures. The following guidelines are established for proper management and maintenance after the implementation of the measures.

Training and awareness. Training should be provided for the people in charge of the operation of the new equipment (e.g., new boiler). The training should include proper maintenance as well. Additionally, awareness should be raised of the importance of energy conservation for all the building users.

Operations and Maintenance (O&M) Plans. Detailed operations and maintenance plans should be created and followed by the personnel responsible. These plans should include procedures for regular maintenance, problems during operation and the responsibilities of all involved personnel.

Monitoring and data collection. The data collection should involve, but not limited to, energy usage, renewable energy generation, and indoor environmental conditions. The proposed measures have common reference conditions (they depend on the determined indicator, e.g., heat transfer coefficients) and the results can be monitored through electricity and heating bills. Data on energy consumption from the bills should be constantly monitored, and if there is a significant increase in energy consumption, and the weather conditions have not changed significantly, it is mandatory to check the systems in the facility. The period for which monitoring, measurement, and verification of the implemented measures to improve energy efficiency will be carried out is until the end of the lifetime of the installed system.

Performance verification. The performance should be verified periodically for all of the implemented measures in order to ensure they are functioning properly.

Regular energy audits. The energy audits should verify the performance of the measures, help in the creation of the operation and maintenance plans, but as well, they will identify new opportunities for energy efficient improvements and renewable energy utilization.

By integrating these practices into the building's management approach, it becomes more likely that energy efficiency measures and renewable energy installations will continue to deliver sustainable benefits over the long term.

Conclusions and Recommendations

General guidelines and recommendations

The objective of the guidelines and recommendations based on the analysis in the report to support of the efforts of the Government of the Republic of Moldova to improve energy efficiency and increase share of renewable energy resources in response to the energy crisis:

Procurement. Integrate energy efficiency criteria into public procurement practices, encouraging the purchase of energy-efficient equipment and materials for government buildings.

Regular Energy Audits. Conduct regular comprehensive energy audits of the buildings to identify areas of inefficiency and potential energy-saving opportunities as well as to create regular action plans in the buildings.

Training and Capacity Building. Investment in training and capacity building for government personnel and facility managers to improve their understanding of energy efficiency technologies and practices would result in better operation and maintenance, as well as better energy management and reduced bills.

Energy Management Systems. Regularly monitor energy consumption, assess the impact of implemented measures, and adjust strategies for continuous improvement. Develop and promote energy management programs for public buildings, including benchmarking energy performance against similar buildings to drive continuous improvement.

Data Collection and Reporting. Establish a centralized database to collect and analyse energy consumption data from public buildings, enabling informed decision-making and policy evaluation.

Renewable Energy Targets. Set renewable energy targets for public buildings and provide support for the integration of renewable energy systems, such as solar panels or geothermal heat pumps.

Public Awareness Campaigns. Engage building occupants through awareness campaigns and education on energy-efficient practices, encouraging them to adopt more sustainable behaviors. Launch public awareness campaigns to educate building occupants and the community about energy efficiency, encouraging responsible energy use.

Prioritize measures. Consider that the measures are interconnected. For example, before changing the energy generation, first lower the energy demand. That way, the new system for energy production will be properly optimized.

By adopting these guidelines and recommendations, buildings can take a systematic and holistic approach to energy efficiency, starting with the optimization of the building envelope and gradually incorporating renewable energy solutions as needed. This approach often leads to more cost-effective and sustainable outcomes in the long run.

Technical guidelines and recommendations

Guidelines for installation of thermal insulation on exterior walls

All materials and components, including insulating boards, adhesive materials, plasters, paints, etc. they must be suitable for use in external thermal insulation systems and to be exposed to the most extreme weather conditions in the building location.

All metal parts must be manufactured specifically for use in external thermal insulation systems and applied according to the manufacturer's instructions to prevent corrosion.

For an effective thermal insulation of the plinths, it is recommended to use extruded polystyrene plates or heat-insulating material with similar characteristics.

Glass fiber or metal mesh (for fixing the plaster) with a regular and reinforced profile is used as reinforcement, intended for the protection of the surface that can be subjected to mechanical stress. The nets, depending on the destination, must be alkali-resistant or treated with alkali-resistant compositions, and/or have an anti-corrosive coating.

All corners will be reinforced with special corner profiles and two layers of mesh.

Horizontal edges at the top of windows/doors and other building soffits shall be reinforced with a special edge drip profile to prevent water from entering the insulation material.

Guidelines for installation of thermal insulation on roof

All materials and components, including insulation boards, adhesive materials, plasters, paints, etc. must be suitable for use in external thermal insulation systems and to be exposed to the most extreme weather conditions in the building location.

All metal parts must be manufactured specifically for use in external thermal insulation systems and applied according to the manufacturer's instructions to prevent corrosion.

Guidelines for installation of thermal insulation in basement

All materials and components, including insulation boards, adhesive materials, plasters, paints, etc. must be suitable for use in external thermal insulation systems and to be exposed to the most extreme weather conditions in the building location.

All metal parts must be manufactured specifically for use in external thermal insulation systems and applied according to the manufacturer's instructions to prevent corrosion.

Guidelines for replacement of windows and doors

Windows and doors shall have opening mechanisms to open in a manner like the windows/doors being replaced unless the designer specifies openings differently.

All windows and doors that open must be equipped with strong metal locking mechanisms and handles.

The replacement of windows and doors must necessarily be combined with measures to ensure adequate ventilation of all rooms.

Guidelines for solar thermal collector systems

The solar collector system must be sized with the optimal surface, considering the optimal angle of inclination and to capture solar radiation to the maximum.

Circulation pumps must have an energy efficiency index of no more than 0.20.

Materials used for outdoor applications must be resistant to ultraviolet rays/solar rays.

Fasteners must be made of high-quality, corrosion-resistant materials.

Mounting systems must be designed to resist corrosion, UV degradation, wind loads and seismic loads appropriate to the region.

All system pipes must be thermally insulated.

Frost protection of the solar system must be provided.

The system must operate automatically, stop, start, etc.

A device for recording and displaying the thermal energy production of the system must be installed.

The expansion tank must be chosen correctly, resistant to pressure and high temperatures.

Solar collectors must have EN 12975-1 conformity certificates as well as Solar Keymark certificates.

The warranty period for the circulation pump of at least 3 years.

Guidelines for photovoltaic systems

Photovoltaic systems must be sized with the optimal surface, considering the optimal angle of inclination and to capture solar radiation to the maximum, being oriented and inclined in such a way as to avoid shading during the day.

Fixing and anchoring solutions for roof-mounted photovoltaic systems must be considered the recommendations in the building/roof technical expertise report.

Roof piercing work, for roof mounted PV systems, must be sealed using appropriate methods that do not adversely affect the roof warranty.

Guidelines for solid biomass boiler (pellets)

The level of emissions must fall within the limits of the EN 303-5:2021 standard and according to the regulations in force.
The scheme of the heating system must be designed depending on the type and activity of the institution.

Circulation pumps must be mounted on the return and have an energy efficiency index of no more than 0.20.

The heating system must be equipped with a bypass pipe and a water treatment plant (softener).

The heat accumulator must have an anti-corrosive layer, with a thermal insulation layer of at least 50 mm, with control sensors and visual control devices.

The pipes of the thermal plant must be made of galvanized steel.

Stainless steel chimney, insulated, equipped with cleaning door, condensate drain valve, terminal element mounted in the upper part of the chimney.

The heating system must be equipped with an alternative power supply source, uninterruptible power supply (UPS) or electric generator.

The heating system must be equipped with thermal energy measuring devices, with remote data transmission options.

Guidelines for air-to-water heat pumps

The system will be equipped with a fire protection system in accordance with the national legislation and regulations in force.

Materials used for outdoor applications must be resistant to ultraviolet rays/solar rays.

Economic guidelines and recommendations

The guidelines will be used in the pre-feasibility study process to identify energy efficiency measures and assess investment costs depending on the measures selected and the financial means available.

The indicators for the recommended Categories of Works for the energy performance include: (1) value of materials, including transport and purchase and storage costs; (2) labour costs, including social and medical insurance; (3) operation of equipment at market prices of the second quarter of 2023.

ICWs for ensuring the energy efficiency of public buildings do not depend on the building category, being common for schools, kindergartens, hospitals, administrative buildings, etc.

The ICW will be updated when the pre-feasibility study or energy audit report is prepared.

The indicative investment value of the selected energy efficiency measures is calculated on the basis of the algorithm developed in accordance with the legislative and regulatory framework in the Republic of Moldova. In case of changes in the normative acts mentioned in the document, only the percentages need to be changed, the calculation algorithm does not change.

Energy auditors to select and argue energy efficiency measures for public buildings will focus on the economic assessment indicators: capital commitment, payback period and net present value.

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ANNEXES

Annex 1. Terms and definitions

According to BRM - Building Regulations Moldova

Resource method - a method of determining prices for construction products by calculating current prices and rates the cost elements (resources) required to complete the project.

Current price level (current prices) - prices in effect at the time of value determination.

Construction value - a generic term used in various value documents that are part of the set of technical documents for the execution of investment objectives.

Investment objective - construction, reconstruction, extension, technical reuse of enterprises, capital or current repair of buildings and constructions, restoration works.

The estimated value of the construction - the amount of money needed to carry out the investment objectives in accordance with the project.

Investor's estimate - generic name for the set of value documents, prepared at the request of the investor (beneficiary), which are part of the feasibility studies or project documentation of the construction. The investor's estimate shows the total value of the estimate for the realisation of the investment objective, including the value of technological equipment, research and design works, maintenance of the investor's service in charge of the realisation of the project, etc.

Contractor's estimate (tender estimate) - generic name for the set of value documents drawn up by the contractor on the basis of the tender documents declared (submitted) by the investor. This documentation shows the value of the works and the costs offered by the contractor for execution (tender value).

Estimate norms - the average consumption of resources per estimate item (materials, labour, construction-assembly machinery), established per unit of measurement of construction, assembly, etc. Estimate norms comprise the whole complex of operations necessary for the execution of a given category of work under normal average conditions. When carrying out work in non-normal conditions (cramped conditions, air polluted with gas, in the vicinity of machinery in operation, etc.), coefficients approved by the National Construction Management Body are applied to the cost estimate standards.

Estimate documentation - documentation drawn up to determine the estimated value for the execution of the buildings and constructions designed. The estimate documentation consists of: lists of quantities of works, resource schedules, local calculations and estimates, individual unit price catalogues, calculations and estimates by the object, estimate calculations by type of expenditure, general calculations and estimates, expenditure centralisers, etc.

Direct expenditure - expenditure on wages and salaries taking account of social security and health insurance contributions, expenditure on the operation of construction equipment, expenditure on the purchase of materials, articles and construction elements taking account of transport costs and expenditure on purchase and storage.

Overhead expenditure - expenditure that accounts for the expenses of the contractor organizations related to the creation of the general conditions of construction production (construction conditions), servicing, organization and management of construction.

Estimated benefit - the number of funds required to cover part (total) of the overhead costs of the contracting organization, which are not included in the cost price of the works and which is the normative (guaranteed) part of the value of the construction product.

Expenditure - consumption of material means, labour, energy, etc. to satisfy needs, obligations, etc.

Cost - The amount of money spent to produce or buy a good, perform work, provide a service, etc.

Investment (I) - The placement of money into an action, project or operation to create an increase in wealth; an expenditure made in the present, certain, for the purpose of achieving future, often uncertain, effects. The cost incurred up to the point when the building (or building element) is delivered to the customer, ready for use.

Total cost (TC) - the sum of the present value of the initial investment costs (I), the annual costs in service (CS) and the replacement costs (RC) reported to the starting year, and the disposal costs (residual value - RV), if applicable.

Cost in service (CS) - a cost that includes maintenance cost, operational cost and energy cost for the time period considered.

Maintenance cost - cost for measures to rehabilitate and ensure the desired quality of the building, building element or facility. It includes annual costs for inspection, routine repairs as part of preventive maintenance, cleaning, adjustments, and consumable items.

Operating cost - cost related to the operation of the building, including annual costs for insurance, utility and other ongoing taxes and fees.

Energy cost - fixed and peak energy costs and charges, including national taxes.

Lifespan - the period of time during which the construction is in use and during which the condition of the load-bearing components meets the established criteria. The physical lifetime depends on the degree of durability of the construction.

Economic life - the period of time during which the asset generates economic benefits (income).

Replacement Cost for component or system (RC) - the replacement investment for a building element according to the estimated economic life cycle during the calculation period.

Residual value RV (disposal cost) - the cost of demolition at the end of the life of a building or building element and includes demolition, removal of building elements that have not yet reached the end of their life, transportation and recycling.

Cost due to greenhouse gas emissions - monetary value of the environmental damage caused by CO2 emissions related to energy consumption in buildings. CO2 emissions are the effects of all greenhouse gases, weighted according to their global warming potential, expressed in kilograms of CO2 over 100 years (EN 15978).

Price indexes (rate of price change) - the change over time in prices for energy, products, building systems, utilities, labour, maintenance and other costs, which may differ from the rate of inflation.

Discount rate - is the rate of return used to convert an amount of money, to be paid or received (saved) in the future, into its discounted (or present) value. Theoretically, it should reflect the opportunity cost of capital; e.g., the rate of return that can be earned on capital if it is put to other uses with the same risk.

Total unit cost - the cost obtained by dividing the overall cost by the calculation period and building area.

According to NAS - National Accounting Standards

Construction contract - a contract concluded between the beneficiary and the contractor for the construction, repair, modernisation and reconstruction of an asset or group of assets, which in design, technology and operation or purpose are related and interdependent.

Contract costs - the number of resources consumed and personnel costs for the performance of one or more construction contracts for the purpose of earning revenue and to be recovered by the beneficiary.

Direct contract costs - costs that are directly related to the execution of work under the construction contract and that can be directly included in its cost.

Actual contract costs - the sum of pre-contract costs and costs actually incurred for work carried out after the conclusion of the contract up to the reporting date.

Pre-contractual costs - costs directly related to the conclusion of a construction contract and incurred before its decision.

Estimated total contract costs - the sum of contract costs actually incurred and recorded at the reporting date plus estimated costs to complete the contract, taking into account possible subsequent changes and claims.

Estimated contract completion costs - material and personnel costs, subcontracting costs and other costs required to complete a contract within a specified period.

Indirect contract costs - costs related to several construction contracts that cannot be directly included in their costs.

Construction management costs - costs associated with the management, organization and servicing of one or more contracts as a whole per entity and on separate sites.

Contract costs - the number of costs actually incurred in relation to the construction contract as a whole or stages of its execution related to the contract revenue recognised.

Contract revenue - the amount of initial income, contract amendment revenue, claims revenue and incentive revenue earned from performing the construction contract.

Annex 2. Composition of direct contract costs

According to NAS „Construction contracts" direct contract costs include:

1) pre-contractual costs related to contracts concluded, including delegation costs, agency costs, tender fees for obtaining the contract, and other similar costs;
2) direct material costs, including the cost of building materials, fuel, electricity, heat, compressed air, steam and water, and other materials used in the process of performing the contract;
3) direct personnel costs, including:
(a) costs relating to the salaries of personnel directly carrying out technological operations and supervising the work under the contract;
(b) compulsory state social security contributions and compulsory health insurance premiums calculated on the salaries referred to in point 3(a) of this Annex;
(c) other direct personnel costs;
4) the direct operating costs of construction equipment, machinery, technical installations, tools and equipment (hereinafter - machinery and equipment) used directly in the performance of the contract, which includes:
(a) the cost of electricity, fuel, spare parts and other materials used for the maintenance and repair of equipment and machinery;
(b) costs of personnel employed in the operation and servicing of machinery and equipment;
(c) mandatory state social security contributions and mandatory health insurance premiums calculated on the salaries referred to in paragraph 4(b) of this Annex;
(d) depreciation of machinery and equipment;
(e) costs of transporting machinery and equipment to/from the construction of the object;
(f) costs of hiring machinery and equipment;
(g) costs of mandatory insurance of machinery and equipment;
(h) other costs relating to the operation of machinery and equipment;
5) other direct costs related to the contract, which may include:
(a) costs of transporting materials from the warehouse on-site to the object of construction and from the central warehouse to the object;
(b) design and technical assistance costs directly attributable to the contract;
(c) debt costs directly attributable to the contract capitalised in accordance with the NAS "Debt Costs";
(d) costs of litigation and claims recognised by the beneficiary or established by court decision. In the event that the beneficiary does not recognise the claims submitted, such costs shall be recognised as current expenses;
(e) amortisation of intangible assets used directly in the performance of the contract;
(f) costs of work carried out and services provided by subcontractors and other third parties;
(g) compulsory insurance for staff directly employed on the construction of the object and the construction work carried out;
(h) the costs of guarding the object of construction;
(i) the calculated depreciation of temporary constructions (not provided for in the list of headings);
(j) provision for guarantee costs relating to the construction contract;
(k) costs of transporting workers to/from the construction object, as provided for in the contract;
(l) other costs directly attributable to the construction contract.

Annex 3. Calculation of the average hourly wage of construction workers for determining the estimated value of the contracting authority's estimate and the contract prices of the construction objectives in the public works procurement procedure.

According to CPC AMENDMENT L.01.02:2012/A2:2022

1. Initial data for calculating the average hourly wage of construction workers by industry:

- according to the Agreement on the amendment of the Collective Agreement in the construction industry for the years 2018 - 2022 (published in the Official Gazette of the Republic of Moldova, no.19-25 of 21.01.2022) the (negotiated) tariff salary for category 1 qualification in the construction industry is 5,000 (five thousand) lei, which includes the complexity coefficient 1.3 for the construction industry (according to the provisions of Annex 3 of G.D. no. 743/2002), calculated for a full work schedule of 169 hours on average per month;
- the bonus for the length of service (on average 15 years) - 25% (G.D. No 844/1995) - if stipulated in the individual employment contract, in the collective employment contract;
- compensation for work under unfavourable conditions - 4.0% (according to G.D. 198/2001), if these have occurred;
- payment for non-working holidays - 6.2% (Labour Code No 154/2003, Art. 111), if working on public holidays;
- leave allowance - 12.3% (Labour Code No 154/2003, Articles 112 and 117), is paid on a compulsory basis;
- a surplus salary on leave (incentive payments) - 10% (Labour Code No 154/2003, Art. 137), if stipulated in the individual employment contract or collective labour contract;
- average salary category - 3-5 (tariff coefficient - 1,81, Annex no. 1 of G.D. no. 743/2002);
- average working hours per month - 169 hours;
- 0.000763 - the share of the average hourly wage corresponding to the 3-5 category of the grid approved in constant 1991 prices for the transition to current prices.

2. Calculation of the average hourly wage of construction workers by branch:

(a) Calculation of bonuses, supplements, allowances, incentive payments and allowances to the tariff wage (basic wage):

	The structure of the salary fund:	Calculation formula	Result, %	Argumentation
1	Tariff salary (basic salary)		100	
2	bonuses, supplements, add-ons, incentive payments and allowances, including:			
2.1	Length-of-service bonus	25.0% x r.1	25.0	G.D. no. 844 of 25.12.1995 on the method of establishment, calculation and payment of the monthly long-service bonus to the staff of construction organizations (O.G. no.13 of 29.02.96), amended by G.D. no.547 of 07.10.96;

				Collective agreement No 231 of 18.12.2018 in the construction industry for the years 2018 - 2022 (as amended)
2.2	The incentive payment for work under adverse working conditions	4.0% x r.1	4.0	1. G.D. no. 198 of 12.03.2001 of 12.03.01 on the approval of the Collective Labour Contract (national level) between the Government of the Republic of Moldova, Employers (O.G. no.31-34, 2001, art. 233, pct,64); 2. G. D. No. 152 of 19.02.2004 on the amount of compensation for work in unfavourable conditions (O.G. No. 39-41, 2004, art. 299).
2.3	Payment for non-working holidays	*12 : (365-112) x 100% = 4.74 4.74x1.25 x 1.04 = 6.2 %*	6.2	Article 111 of the Labour Code No.154 of 28.03.2003 (Official Gazette No.159-162, 2003, Art.648)
2.4	Leave allowance	*(r.1 + r.2.1 + r.2.2 + r.2.3) = 135.2 1/11 din 135.2 = 12.3 %*	12.3	Art. 112, 117 of the Labour Code No. 154 of 28.03.2003 (Official Gazette No. 159-162, 2003, Art. 648)
2.5	A surplus salary on leave (incentive pay)	*(r.1 + r.2.2 + r.2.3):11 = 110.2:11 = 10 %*	10.0	Article 137 of the Labour Code No.154 of 28.03.2003 (Official Gazette No.159-162, 2003, Art. 648)
	Total bonuses, supplements, and add-ons: (r. 2.1 ÷ r. 2.5)		**57.5 % K=1.575**	

(b) Calculation of the average hourly wage of construction workers by branch according to the tariff network (according to Annex No. 1 to Government Decision No. 743/2002 on the wages of employees in units with financial autonomy (Official Monitor of the Republic of Moldova, 2002, No. 79-81, art. 841)):

Wage calculation according to the Agreement amending the Collective Agreement in the construction industry (2018-2022)

Tariff coefficients	Categories	Tariff wages, lei/hour	Tariff salaries, lei/month
1,00	1	29.59	5 000
1,26	2	37.28	6 300
1,59	3	47.04	7 950
1,81	4	53.55	9 050
2,07	5	61.24	10 350
2,36	6	69.82	11 800
2,69	7	79.59	13 450
	Average (3+4+5) : 3	**53.95**	**9 116.67**
Average hourly wage with K=1.575		**84.97**	**14 359.93**

The average hourly wage rate for construction workers by branch (for categories 3-5) is [(47.04 + 53.55 + 61.24): 3 = 53.95 lei/hour)].

5. Taking into account bonuses, supplements, allowances, incentive payments and compensation at the rate of pay (57.5% or coefficient 1.575), the average hourly wage of construction workers by the branch is 53.95 x 1.575 = 84.97 lei/hour.

6. The updating of the average hourly wage of construction workers in current prices in relation to the level of constant prices of 1991 (for the construction objectives, the cost of which was calculated by the old method in force until 01.01.2003) is carried out by applying the index for updating the level of wages, Irm = 88 020.97. (84.97 lei/hour: 0.000763 = 111 363.04).

Annex 4. List of items of expenditure, covered by the cost estimate profit account, provided for in the contract price for construction production

According to CPC L.01.05-2012

1. Entrepreneurial expenditure
1.1. For the determination of the cost estimate benefit norm, the following costs of the contractor, not included in the cost price of the contractor's work, are taken into account;
1.2. Expenditure on taxes, duties and other compulsory payments (except income tax):
1.2.1. taxes, charged to the road fund;
1.2.2. local taxes and charges: land tax, property tax, land use planning charges;
1.2.3. other mandatory payments.
1.3. Expenditure on the payment of interest on bank loans and borrowings obtained on a short or long-term basis, except where these are capitalised.
1.4. Commercial expenditure on advertising (including participation in exhibitions, auctions).
1.5. Material aid granted to employees including the initial share for the partial repayment of the individual housing loan.
1.6. Expenditure on health care, leisure and rest activities for employees of the enterprise, i.e.: for the payment on the enterprise's account of tickets for sanatoriums and rest homes, expenditure on the organization of cultural, entertainment and sports activities.
1.7. Deducted means for trade unions -0.15% of the labour compensation fund.
1.8. Differentiated means for measures to improve working conditions and safety at work -2% of the amounts spent on compensation of employees.
1.9. Charitable and sponsorship expenditure.
1.10. Other expenditures are to be deducted from revenue when determining financial results.
2. Production development expenditure
2.1. Modernisation of equipment, reconstruction of fixed assets.
2.2. Partial replenishment of own working capital.
3. Income tax

Annex 5. Expenditure limits for the maintenance of the beneficiary's service

According to CPC L.01.01-2012

1. The expenditure limits for the maintenance of the management (technical supervision) in construction apply to the determination of the estimated value of the objective in the general estimates for technical projects (for execution projects) in the following values:

In the case of the estimate value of the objective	Territorial location of construction objectives	%
up to 50 million lei (technical supervision)		1.1
up to 50 million lei (where the beneficiary's service operates)	1 locality	2.14
up to 50 million lei (where the beneficiary's service operates)	More than 1 locality	2.32
From 50 mil lei up to 100 mil lei	1 locality	1.41
From 50 mil lei up to 100 mil lei	More than 1 locality	1.53
From 100 mil lei up to 150 mil lei	1 locality	1.32
From 100 mil lei up to 150 mil lei	More than 1 locality	1.43
From 150 mil lei to 200 mil lei	1 locality	1.23
From 150 mil lei to 200 mil lei	More than 1 locality	1.34
From 200 mil lei to 300 mil lei	1 locality	1.13
From 200 mil lei to 300 mil lei	More than 1 locality	1.24
From 300 mil lei to 500 mil lei	1 locality	1.08
From 300 mil lei to 500 mil lei	More than 1 locality	1.18
From 500 mil lei to 2000 mil lei	1 locality	1.0
From 500 mil lei to 2000 mil lei	More than 1 locality	1.1

2. The norms presented do not include expenditure related to the activity of provisioning, conservation and storage of unfinished construction objectives. The expenditure referred to shall be financed from other sources in the manner laid down.

3. Expenditure limits for the maintenance of construction companies and units (technical supervision of the beneficiary) apply to construction objectives, executed on behalf of the state budget and budgets of administrative-territorial units. In necessary cases, the reimbursement of insufficient means for the maintenance of the beneficiary's service is allowed to be made on account of unforeseen expenditure, established in the general estimate. At the same time, funds from the budgets of the administrative-territorial units may be used for the maintenance of the beneficiary's single service.

4. In the case of objectives to be carried out from the own resources of legal or natural persons, the means for the maintenance of the beneficiary's service shall be determined by agreement between the beneficiary (authorising officer) and the holder (investor) in accordance with CPC L.01.08-2012.

Annex 6. Example of estimating the value of the building energy efficiency measures

Technical parameters of a school building:
Surface area of the fasads (excluding the surface area of voids) – 2279 m^2
Surface of voids (windows, doors) – 696 m^2
Basement area – 1302 m^2
Roof surface – 1447 m^2
Number of light bulbs inside the building – 1464
The number of bulbs for outdoor lighting - 12

Nr.	Theme	Name of expenditure	Calculation formula	u.m.	ICW, lei/u.m	Quantity	Amount, lei
1	**Chapter 1. Construction works**						
1.1		Insulation of the basement with mineral wool with hydrophobic coating, 10 cm thick		m2	389	1302	506 478
1.2		Insulation of walls with expanded polystyrene, 8 cm thick		m2	738	2279	1 681 902
1.3		Insulation of the attic floor with mineral wool, 10 cm thick		m2	339	1447	490 533
1.4		Replacement of windows with double-glazed PVC package, replacement of doors		m2	3174	696	2 209 104
1.5		Total	r.1.1+1.2+1.3+1.4				4 888 017
1.6		Overheads	14.5% of 1.5.		14.50%		708 762
1.7		Total	r.1.5+r.1.6				5 596 779
1.8		Contractor profitability	6% of 1.7		6%		335 807
1.9		**Total Chapter 1**	r.1.7+r.1.8				**5 932 586**
2	**Chapter 2. Assembly work**						
2.1		Indoor electric lighting		unit.	30	1464	43 920
2.2		Outdoor electric lighting		unit.	108	12	1 296
2.3	Contract	Value of equipment: indoor LED bulbs		unit.	58	1464	84 912
		outdoor LED bulbs		unit.	720	12	8 640
2.4		Total	r.2.1+r.2.2				45 216
2.5		Overheads	76% of r.2.4		76%		34 364
2.6		Total	r.2.4+r.2.5				79 580
2.7		Contractor profitability	6% of 2.6		6%		4 775

2.8		**Total Chapter 2**	r.2.6+r.2.7+r.2.3				**177 907**
2.9		**Total Chapter 1 and 2**	r.1.9 + r.2.8				**6 110 493**
3	**Chapter 3. Other expenditure**						
3.1	CPC L.01.01-2012 p.6.6	Additional costs for workers' transport, travel expenses, etc.	0.9% of r.2.9		0.90%		54 994
3.2	CPC L.01.01-2012 Annex C	Technical surveillance	According to Annex 5. in % of r.2.9		1.10%		67 215
3.3		**Total Chapter 3**	r.3.1+r.3.2.				**122 210**
4	**Chapter 4. Design work, surveys, author control**						
4.1	Contract	Design works					
4.2	CPC L.01.01-2012, pct.6.10.2	Carrying out author control of the construction object by design organisations	0,3% of r.2.9		0.30%		18 331
4.3	CPC L.01.01-2012, pct.6.10.3	Carrying out expert appraisal of feasibility documentation, project documentation and cost estimate	According to current tariffs				15 000
4.4		**Total Chapter 4**	r.4.1+r.4.2+r.4.3				**33 331**
5		**Total Chapter 1-4**	r.2.9+r.3.3+4.4				**6 266 035**
6	CPC L.01.01-2012, pct. 6.11	Reserve for unexpected expenditure	2% of r.5		2%		125 321
7		Total	r.5 + r.6				6 391 355
8	CPC L.01.01.2012 pct. 6.14	VAT	20% of r.7		20%		1 278 271
9		**TOTAL PROJECT**	r.7 + r.8				**7 669 626**

Annex 7. Recommended sources for determining the value of the indicators used in the economic efficiency calculation

For the economic evaluation of projects to ensure the energy performance of public buildings, we recommend the use of:

Indicator		**Value**	**Reference sources**
Calculation period		30 ani years	According to SM EN 15459-1:2017
Discount rate	In case it is positive value	Real interest rate = nominal rate - forecast inflation rate	According to SM CEN/TR 15459-2:2017 Base rate, NBM https://www.bnm.md/ Forecast inflation rate, Ministry of Finance https://www.mf.gov.md/ro/buget/cadrul-bugetar-pe-termen-mediu
	In case the real interest rate is negative[36]	Effective interest rate for government bonds with maximum maturity	According to NBM data https://www.bnm.md/bdi /pages/reports/dop/DOP5.xhtml
Investments		Lei	According to Table 26 in Chapter IV
Costs in service	Maintenance	% of initial investment	According to SM EN 15459-1:2017 Annex D (includes service life and % of maintenance cost)
	Operational	% of initial investment	According to SM EN 15459-1:2017 Annex E (includes types of installation costs)
	Energy cost	Fees valid at the valuation date	According to ANRE data https://anre.md/tarife-in-vigoare-3-204
Replacement costs		Cost of equipment / installations to be replaced	Market analysis

[36] For example:
in April 2023 according to the BNM https://www.bnm.md/, Nominal base rate = 14% and projected inflation rate, according to the MTEF (Medium Term Budgetary Framework) https://www.mf.gov.md/ro/buget/cadrul-bugetar-pe-termen-mediu, annual average 2023 = 15.7%, in 2024 = 5.9%, in 2025 = 5%.
The real rate is therefore - 1.7% in 2023, +8.1% in 2024 and +9% in 2025.

Guide for the implementation of energy efficiency measures and valorization of renewable energy sources for public sector buildings

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