Hungary Slovakia Romania Ukraine

PARTNERSHIP
WITHOUT BORDERS

NESiCA

Hungary-Slovakia-Romania-Ukraine
ENI CBC Programme 2014-2020

BEST SOLUTIONS
IN CARPATHIAN REGION

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CONTENT

INTRODUCTION

"Best solutions in Carpathian region" was developed by the International Consortium of Partners of the "New Energy Solutions in Carpathian area" project, implemented with the financial support of the ENI CBC Hungary-Slovakia-Romania-Ukraine 2014-2020 Programme from 01.05.2020.

The cross-border area of Ukraine, Hungary, Romania, and Slovakia is a single and compact cross-border area that has similar characteristics and challenges. Energy is the factor with the most significant impact on economic and tourism development, being an essential element of sustainable development, therefore the efforts made by each of us to improve the way we use energy must become a priority. But till today renewable energy sources have a minimal role in the current energy structure. Energy education is fundamental and is the long-term solution to cultivating people's green living senses. Besides, there are great needs in communities/small cities and villages in making effective decisions in saving energy and using renewable resources of energy. The project makes a great contribution to global GHG emission reduction with implemented pilots aimed to protect the environment and its resources.

Therefore, the main **objective** of the project is to promote energy efficiency and renewable energy sources through education activities in Universities and communities aimed at sustainable use of the environment in border regions.

Moreover, the following objectives may be identified:

- providing strategic approach in energy efficiency and renewable energy sources in border regions through the development the Cross-Border Cooperation Energy Concept for pilot communities and Universities based on the clusters approach;
- raising awareness, competence and skills of the population in border regions in protecting the environment and to contribute to the global GHG emission reduction provided by joint activities and cooperation establishment of the joint institutional base, sustained informational flow in energy sector; establishment of specialized energy innovation centres and laboratories in each target region for providing energy monitoring, efficiency and renewable energy sources using and providing support for communities and young specialists as well as students; creating trained teams in each partner region through common trainings of the personnel, holding thematic workshops, trainings and best practices exchange sessions;
- increasing the presently low energy efficiency by joint initiatives, namely: energy innovation system for swimming pool in UzhNU, energy storage system for Technical University in Kosice, Established Energy Laboratories for communities in Nyiregyhaza, Suceava and Uzhhorod aimed at energy monitoring, development of the concepts of the new solutions for pilot communities and University buildings.

The **International Consortium** of Partners consists of Uzhhorod National University (Ukraine), Self-Government of the Sabolc-Satmar-Bereg Region (Hungary), Stefan cel Mare University in Suceava (Romania), Public Organization "Center for European Initiatives" (Ukraine), Technical University in Košice (Slovakia), University in the city of Nyíregyháza (Hungary).

According to the results of the project, the regional situation of sustainable use of the environment in the border regions has been improved due to effective and innovative energy solutions in communities, which are provided as a result of cooperation with universities and professional institutions. A strategic approach to energy efficiency was introduced, and energy efficiency activities were harmonized across borders. The population has received new educational sessions and informational exchange.

As a project **result** energy efficiency laboratory for communities "NESiCA" were formed in Uzhhorod with personnel who took part in training aimed at the effective use of laboratory equipment, conducting energy audits, creating energy management systems and using the best practices of European countries. The training was conducted by specialists of the "Ștefan cel Mare University" of Suceava in Romania and the Adamson Energy Service Company in Ukraine. The aim of the laboratory is to provide services for determining the sources and amount of inefficient use of fuel energy resources, hot and cold water, electricity and thermal energy, identifying the potential for energy saving and developing effective measures aimed at increasing the energy efficiency of a complex of buildings, including technical and economic assessment and impact on the environment at communal and private property in Zakarpattia region and beyond.

Within the framework of the project all partner regions have conducted energy audit of different types of buildings. An energy audit is an effective solution that will help reduce the amount of consumption costs, due to the reduction of the amount of energy consumption through the implementation of energy efficiency measures. Conducting an energy audit is the basis for determining the problems of energy consumption and energy efficiency of the building. As a result of the conducted audits communities have not only determined the consumption needs of the building, but also received Measure Plans to overcome them.

The following communities have been identified for conducting the energy audit in each partner region:

1. In Romania: Liteni, Șcheia, Vama communes.
2. In Hungary: Kemecse, Záhony and Tiszalök settlements.
3. In Ukraine: Vilkhovetska, Dubove, Kholmok territorial communities.
4. In Slovakia: Zborov, Nová Bašta, Sady nad Torysou communities.

The project made a great contribution to increasing the awareness of the local population, communities and institutions regarding the renewable energy technologies among population in border regions. The developed Joint Energy Concept in the framework of the "NESICA" project provides great possibilities for renewable energy production in communities, institutions, as well as buildings.

2. CURRENT SITUATION, NEEDS AND CHALLENGES IN TARGET REGIONS

Target areas have great needs in harmonization of local renewable energy strategies in solar, biomass, hydro power and geothermal energy. The problem and the challenge of Zakarpatska and Szabolcs-Szatmar-Bereg regions is the lack of skilled experts in energy efficiency caused by: absence of the harmonized local renewable energy strategies, absence of educational energy manageme the University of Nyiregyhaza. Some of border regions already have the concepts of using the renewable energy and provide their implementation. Population in border regions on the EU and non-EU sides have different levels of understanding the importance of the environmentally friendly and innovative technologies. For example, in EU countries there are regulations regarding the necessity to install renewable energy system in each new building that should be provided at the stage of planning, designing and receiving permission for building/reconstruction. Besides, new established communities in Ukraine, small villages in Slovakia, and Hungary, as well as communities in Romania try to reduce the consumption of housing and household energy and also the deriving expenditures. Energy efficiency is therefore becoming a very important issue in the communities, including the cross-border ones.

The project has synergy and related contribution to local and national strategies: Rural Development Programmes for Hungary, Slovakia, Romania 2014-2020, Carpathian Euroregion Strategy 2020, Danube Transnational programme 2014-2020.

European Union requirements. Overall, buildings are responsible for about 40% of the European Union's (hereinafter: 40 %) total energy consumption, and for 36% of its greenhouse gas emissions from energy. The annual energy renovation rate is low at some 1%, - furthermore across the EU, deep renovations that reduce energy consumption by at least 60% are carried out only in 0.2% of the building stock per year - which is far from achieving the set goal, to reach EU-wide climate neutrality by 2050. 85% of the EU's building stock, were built more than 20 years, 85-95% of the buildings that exist today will still be standing in 2050.

Most of these buildings are not energy-efficient, many rely on fossil fuels for heating and cooling, and use old technologies and wasteful appliances. Currently the annual renovation rate of the building stock varies from 0.4 to 1.2% in the Member States. This rate will need at least to double in order to reach the EU's energy efficiency and climate objectives.

The European Union has taken a number of pieces of legislation and initiatives to make buildings more energy efficient and to meet the targets set. The most relevant of these are: Building and renovating - The European Green Deal, New renovation initiative in 2020, A Renovation Wave for Europe – 2020, Renovation Wave Strategy – 2020.

As at the European Union level, buildings are among the largest CO_2 emitters and energy consumers in Hungary. In Hungary 40 % of primary energy consumption is used for the supply of energy to buildings, within which residential buildings account for the largest share with almost 60%. Around 27 % of total final energy consumption in residential buildings, cca. 6 % takes place in public buildings. The industrial sector accounts for almost a quarter of consumption and the services sector (trade, public services, other services) accounts for 12 %, while agriculture accounts for 4 % and transport for 27 %. 40 % of domestic energy use is for cooling and heating purposes. The potential for saving this type of energy is particularly high, as Hungary is among the ten most consumers in the EU in terms of the amount of energy used per dwelling.

Natural gas is the primary fuel currently used for the energy supply of more than 3.7 million residential homes in Hungary, which is used by nearly 76 % of households for heating purposes. At the same time, almost 80 % of the natural gas used is imported.

The renovation rate of the building stock, although showing an increasing trend, is still low, as the renovation rate for residential buildings is only around 1 % per year.

Primary energy consumption in residential buildings is on average between 215 kWh/m2/year and public buildings approximately 214 kWh/m2/year. Compared to other EU Member States, Croatia, the Czech Republic and Poland have nearly similar values, i.e. primary energy consumption exceeds 200 kWh/m2. However, Germany and Austria have buildings with average primary energy consumption below 200 kWh/m2.

In addition to their average age - 81 percent of the Hungarian housing stock was built before 1990 and 42 percent before 1960 - Hungarian residential real estate has low energy efficiency. 22.6 percent of them are up-to-date based on energy quality rating (CC, BB, AA, AA +, AA ++), and only 2.3 percent meet the nearly-zero energy requirements.

Ukraine does not remain aloof from the global challenges of humanity, in particular the problems of climate change and adaptation to these changes. The country is a party to the Paris Climate Agreement and has already expressed its intentions to implement the principles of the European Green Course, in particular, the concept of a "green" energy transition of Ukraine by 2050 was presented. Energy production is the main source of anthropogenic greenhouse gas emissions in the world, and therefore the introduction of renewable energy sources (RES), increasing energy efficiency and energy conservation should be given a key role.

For Ukraine, this means the need to clearly formulate a climate policy and a corresponding energy strategy.

On November 13, 2021, the Law of Ukraine No.1818-IX "On Energy Efficiency" ("the Law") entered into force. The Law deals, in particular, with ensuring energy efficiency during the production, transportation, transmission, distribution, supply and consumption of energy.

Adoption of the Law was carried out in order to fulfill obligations to promote energy efficiency and energy saving at the regulatory and political levels in accordance with the EU standards under the Treaty establishing the Energy Community and the Association Agreement with the European Union and the European Atomic Energy Community.

According to the Law, energy efficiency is the quantitative ratio between work, services, goods or energy at the output and the energy consumed at the input.

The law provides for:

- Creation of a national plan for energy efficiency actions ("Plan").
  This Plan will define all energy-efficient measures in the production, transportation, transmission,

distribution and consumption of energy with the terms of their implementation. In addition, sources of funding for such measures and the estimated amount of energy savings will be established.

- Implementation of energy management systems in state authorities and local self-government bodies.

The law stipulates that state authorities and local self government bodies must create structural units responsible for planning, implementing and monitoring the results of implementing energy-efficient measures, analyzing the consumption of fuel and energy resources, and implementing other measures aimed at increasing the energy efficiency of energy consumers.

- In addition to state authorities and local self-government bodies, the energy management system should also be implemented by business entities that wish to receive state aid for the implementation of energy-efficient measures.
- The obligation of subjects of large enterprises to conduct an energy audit every four years, starting from the day of the first energy audit, has been established.
- According to the Law, an energy audit is a systematic analysis of energy use and energy consumption within the limits determined by the nature and scope of energy audit work, with the aim of determining, quantifying and preparing a report on the possibilities of increasing the level of energy efficiency.
- A centralized information system (the National Energy Efficiency Monitoring System) is being created to track the implementation of the measures provided for by the Law. It will monitor the status of measures provided for by the Law, the systematization and information exchange of all databases containing information on primary and final energy consumption, it has normatively defined relationships, rights and obligations, incentives and counterweights between all participants of information exchange, and as well as the technical characteristics of the work.
- Establishing the obligation for energy suppliers to modernize their networks and equipment based on their energy efficiency potential assessment.

The changes also affected the Law of Ukraine "On Energy Efficiency of Buildings", thereby establishing restrictions for state authorities and local governments. Thus, in the event that they purchase or enter into contracts for renting buildings, the subject of such contracts can only be buildings, the energy efficiency of which is at a level not lower than that established by the minimum requirements for the energy efficiency of buildings.

The purpose of the Law is to establish the legal, economic and organizational foundations of activities in the field of ensuring energy efficiency, ensuring the implementation of energy efficient measures that will be carried out during the production, transportation, transmission, distribution, supply and consumption of energy.

The law will contribute to the creation of conditions for increasing the efficiency of the use of fuel and energy resources in Ukraine, improving the standard of living of the population as a result of reducing the costs of paying for energy resources, rational use of funds from the state and local budgets, which are directed to the compensation of costs related to the use of energy resources, and will contribute to increasing energy independence and energy security of the state.

According to the forecast of the International Energy Agency (International Energy Agency), by 2040 energy consumption will increase by another 30% due to a significant increase in energy demand in developing countries. At the same time, the European Union is today and will remain the leading center of energy efficiency implementation. Having received the status of a candidate for EU membership in June 2022, Ukraine has legally secured its European future, and the preparation for membership will involve the completion of a comprehensive transformation of all spheres. Among them, one of the priorities is, of course, energy efficiency and energy saving at the level of European standards.

After the ratification of the Paris Climate Agreement on July 14, 2016, Ukraine joined this international initiative to combat global warming, one of the main causes of which is considered to be the increase in greenhouse gas emissions into the atmosphere. The main task of the Paris Agreement is to keep the increase in the global average temperature within 1.5-2 degrees Celsius above industrial levels. According to the agreement, its participants are obliged to reduce greenhouse emissions in relation to the indicator for 1990 through Nationally Determined Contributions (NDC).

According to the Second Nationally Determined Contribution (NDC2), Ukraine aims to reduce CO_2 emissions by 65% by 2030 in comparison with the 1990 level. This contribution of Ukraine to the Paris Agreement is, in fact, a concept of state development to achieve ecologically and economically expedient transformations in all sectors of the economy: energy, industry, transport, buildings, agriculture and forestry, and waste management.

Military actions in Ukraine, unfortunately, make corrections in the implementation of this concept, but in no way can prevent the movement of the state in this direction. At the Recovery Conference in Lugano (Switzerland), Ukraine presented a plan to build 30 GW of "green" energy by 2032, which will require $130 billion in investment.

The Recovery Plan is aimed at accelerating sustainable economic growth, energy independence and the Green Deal.

The recovery plan of Ukraine, presented in Lugano, in the first stage by the end of 2022, provides for a 5% increase in energy efficiency in the building sector (by implementing low-cost measures in existing buildings and rebuilding destroyed buildings to a high energy efficiency class). At the stage of economic recovery in 2023-2025, the plan sets the task of introducing and ensuring continuous improvement of the energy management system at the state and municipal level, as well as at enterprises, in particular in accordance with the requirements of standards and international agreements - Increasing energy efficiency in the building sector by 13% (through reconstruction of destroyed buildings to the NZEB (Nearly zero-emission buildings) level and thermal modernization of the most energy-consuming buildings.

In the conditions of decentralization, local self-government bodies receive more and more powers and resources for effective management in all spheres of public life, and the field of energy efficiency, due to the above, should become one of the priorities for reform. The basis for the implementation of energy efficiency in municipal buildings should be the inventory and creation of an appropriate database with at least basic technical and energy parameters.

On the basis of this database, buildings should be prioritized and appropriate action plans and programs for their renovation should be developed. It is desirable for local government representatives to undergo training on the implementation of energy management in communities. Development and conducting of trainings and popularization of energy efficiency and available tools for project implementation among authorities and local self-governments will take place, including in cooperation of the state with international donors. That is why activities to increase the institutional capacity of territorial communities in the field of energy efficiency are among the priorities for the coming years, and these recommendations are also designed to help representatives of local government organizations establish systematic work in this direction in their councils.

3. BEST ENERGY SOLUTIONS – CONCEPTS FOR PILOT COMMUNITITES IN UKRAINE

Requirements of normative documents on energy efficiency

In recent years, legislation in the field of energy efficiency has been actively developed in Ukraine. As part of these actions, two fundamental laws of Ukraine were adopted, which are now the basis in the field of energy efficiency - these are:

- Law of Ukraine On Energy Efficiency of Buildings dated June 22, 2017;
- Law of Ukraine On Energy Efficiency dated October 21, 2021;
- Law of Ukraine On Amendments to Certain Laws of Ukraine on Creating Conditions for the Implementation of Complex Thermal Modernization of Buildings dated July 9, 2022.

These laws define relations arising in the field of ensuring the energy efficiency of buildings, with the aim of increasing the level of energy efficiency of buildings, taking into account local climatic conditions and ensuring proper conditions for living and/or life activities of people in such buildings, and are aimed at strengthening energy security, reducing energy poverty, sustainable economic development, preservation of primary energy resources and reduction of greenhouse gas emissions.

These laws were based on Ukraine's obligations under the Treaty on the Establishment of the Energy Community and the Association Agreement between Ukraine, on the one hand, and the European Union, the European Atomic Energy Community and their member states, on the other hand, these laws are aimed at implementing acquis communautaire of the European Union in the field of energy efficiency, namely: Directive 2012/27/EU on energy efficiency.

With the appearance of these laws in Ukraine, the following concepts gain a clear meaning: energy auditors, energy efficiency certificates, reports on the inspection of engineering systems of buildings, energy audits of buildings and processes; energy management, energy monitoring, etc.

In addition, these laws establish requirements for various players of the energy efficiency market, including local self-government bodies.

Thus, according to the Law of Ukraine On the Energy Efficiency of Buildings, taking into account the changes specified in the Law of Ukraine On Amendments to Certain Laws of Ukraine on Creating Conditions for the Implementation of Complex Thermal Modernization of Buildings, namely:

Article 7:

1. *Energy efficiency certification is mandatory for:*

1) *construction objects (new construction, reconstruction, capital repair, except for objects on which work is carried out, defined by the second paragraph of the first part of Article 6 of this Law), which by the class of consequences (responsibility) belong to objects with medium (CC2) and significant (CC3) consequences, which are determined in accordance with the Law of Ukraine "On Regulation of Urban Development Activities";*

2) *buildings in which they intend to carry out thermo-modernization and/or energy-efficient measures aimed at improving the heat-technical characteristics of enclosing structures, for the implementation of which state support is provided;*

__3)__ buildings in which they intend to carry out thermomodernization and/or energy-efficient measures aimed at improving the thermal characteristics of enclosing structures, for the implementation of which state support is provided;
__4)__ a state-owned building housing executive authorities occupying more than 250 square meters of heated space;
__5)__ communally owned buildings housing local self-government bodies occupying more than 250 square meters of heated space;
__6)__ a building of communal property with a heated area of more than 250 square meters, which is often visited by citizens.

Buildings that are often visited by citizens are determined by the central executive body, which ensures the formation of state policy in the field of energy efficiency of buildings.

Based on the results of energy efficiency certification, an energy certificate is drawn up.

A copy of the extract from the energy certificate is placed in a place (places) accessible to citizens.

The owner or a person authorized by him ensures that the extract from the energy certificate is placed in a place (places) accessible to citizens.

Definition:
accessible place for citizens to familiarize themselves with - a place (places) on the outer surface of the facade of the first floor of a building near the entrance (entrances) to such a building, which is open for free access and inspection;

energy certificate - an electronic document of the prescribed form, which indicates the indicators and class of the energy efficiency of the building, provides recommendations for its improvement formed in accordance with the procedure established by law, as well as other information specified by law. All these points, except for those that are already in force, will come into effect from 08/03/2023.

Article 12-1. Building energy management systems

1. In order to organize and implement energy-efficient measures in buildings, the energy management system of buildings must be implemented and functioned, in particular, in the following budgetary institutions:

1) apparatuses and territorial bodies of ministries, other central bodies of executive power, other state bodies, the jurisdiction of which extends to the entire territory of Ukraine;
2) apparatuses of the Council of Ministers of the Autonomous Republic of Crimea, apparatuses of executive bodies of the Autonomous Republic of Crimea, regional, Kyiv and Sevastopol city, district, district in the city of Kyiv state administrations;
3) enterprises, institutions and organizations belonging to the sphere of management of state authorities;
4) local self-government bodies.

2. The head of the authorized unit, responsible for the implementation and operation of the building energy management system (authorized person), is accountable and under the control of the head of the corresponding state body or local self-government body.

3. Local self-government bodies shall implement energy management systems for buildings, the maintenance expenses of which are carried out at the expense of local budget funds, in accordance with the model provision approved by the Cabinet of Ministers of Ukraine, taking into account the structure determined by the second part of this article.

4. Financing of the implementation and operation of energy management systems of buildings in budgetary institutions is carried out at the expense of the state budget, local budgets and funds received as grants or attracted in another way from any other sources not prohibited by law.

Article 13. Survey of technical installations of the building

1. *Technical installations with a nominal power of 70 kW or more in buildings are subject to mandatory inspection:*

1) *state-owned, in which executive authorities are located, occupying more than 250 square meters of heated space;*

2) *in which local self-government bodies occupying more than 250 square meters of heated space are located;*

3) *in which thermo-modernization and/or energy-efficient measures are carried out, aimed at increasing the energy efficiency indicators of technical installations, for the implementation of which state support is provided.*

In other cases, inspection of technical installations is voluntary.

If maintenance of the technical installation is carried out on a regular basis in accordance with the energy service contract, the inspection of such technical installation is optional.

7. Ensuring a timely inspection of technical installations is carried out by the owner (co-owners) of the building in accordance with the legislation.

8. An extract from the report on the results of the inspection of technical installations is placed in a place accessible to citizens.

The availability of the report on the results of the examination of technical installations in a place (places) accessible to citizens for perusal is ensured by the owner, a person authorized by him.

Definition:

technical installation - a complex of equipment that is part of the engineering systems of the building (buildings) and produces thermal energy for heating, water heating or provides ventilation, cooling, air conditioning.

This article shall enter into force 18 months after the entry into force of this law, as of February 3, 2024.

The final provisions of the Law on Amendments to Certain Laws of Ukraine on Creating Conditions for the Introduction of Complex Thermal Modernization of Buildings indicate that:

6. To local self-government bodies:
within 36 months from the date of entry into force of this Law, ensure that energy efficiency certification of buildings specified in the thirty-third paragraph of subparagraph 4 of clause 6 of section I of this Law is carried out in the prescribed manner;

Here we are talking about mandatory certification of the energy efficiency of buildings in accordance with point: 4) communally owned buildings, which house local self-government bodies, occupying more than 250 square meters of heated space; within 48 months from the date of entry into force of this Law, ensure that the certification of the energy efficiency of buildings specified in the thirty-fourth paragraph of Subitem 4 of Clause 6 of Section I of this Law is carried out in the prescribed manner;

Here we are talking about mandatory certification of the energy efficiency of buildings in accordance with point: 5) communally owned buildings with a heated area of more than 250 square meters, which are often visited by citizens.

Within 42 months from the date of entry into force of this Law, ensure the inspection of the technical installations of buildings specified in the fifth paragraph of Sub-Clause 9 of Clause 6 of Section I of this Law in the prescribed manner.

Here we are talking about the mandatory inspection of technical installations according to p: 2) in which local self-government bodies are located, which occupy more than 250 square meters of heated space.

The date of entry into force of this law is 03.08.22.

In addition to these two laws, the Law on Energy Efficiency also contains articles that concern local self-government bodies, namely:

Article 6. Energy planning at the local level

1. *Local self-government bodies develop local energy plans. The decision to approve the local energy plan is made by the local council.*
2. *The goals and measures of local energy plans are consistent with the national energy efficiency goal and the National Plan.*
3. *The composition, content, procedure for developing and updating local energy plans are determined by the central body of executive power, which ensures the formation and implementation of state policy in the field of development of local self-government, territorial organization of power and administrative-territorial system, state policy in the field of housing and communal services and in the field of energy efficiency of buildings. Sustainable energy and climate action plans containing measures to be implemented to achieve goals in the area of energy efficiency, energy development and adaptation to climate change, including reducing carbon dioxide emissions, can be combined with local energy plans.*
4. *Funds saved as a result of the implementation of energy efficiency measures can be directed to local revolving funds only for the purpose of reinvestment in further investments in energy efficiency*

in the manner determined by the central body of the executive power, which ensures the formation and implementation of the state financial, budget and debt policy.

Article 12. Energy management systems

3. *Local self-government bodies implement energy management systems taking into account the exemplary provision approved by the Cabinet of Ministers of Ukraine.*

The decision on the introduction of the energy management system and the approval of the regulation on the energy management system is taken by the relevant council.

All clauses of this law, with the exception of part 5 of article 12, are effective from 10/21/2021. Part 5 of Article 12 shall enter into force 24 months after the entry into force of this law, i.e. from 21.10.23.

Summarizing the requirements of these laws, it becomes obvious the importance of implementing these services in communities before the end of the deadline, because it opens the opportunity for you to be among the first to receive funding for energy efficiency. In addition, all these norms are to some extent imposed on the period of post-war reconstruction of the country, where funds will be allocated from state financing funds, and their conditions are the presence of energy management systems and certification of buildings. In addition, financing will take place by attracting grant funds, where for most grant providers, this is already a mandatory condition. Knowing and understanding this gives you an advantage over others.

I. DUBOVE COMMUNITY

1. General description of the community

The Dubove settlement territorial community is territorial community in Ukraine, Zakarpattia region, Tiachiv district.

The Dubove settlement territorial community was created in October 2020 through the merger of the Dubove settlement and Kalyniv and Krasnian village councils. Community area: 225.8 sq.km. Population: 20709 people.

The community includes 5 settlements: the village of Vyshnii Dubovets, the village of Nyzhnii Dubovets, the urban-type village of Dubove, the village of Kalyny, the village of Krasna. The minimum distance of settlements to the administrative center is 3 km, the maximum is 18 km. It borders Ust-Chornianska and Neresnytska territorial community.

The administrative center of the community is the village of Dubove. The first mention of the settlement in historical sources appears on January 26, 1591. According to the legend, the name of the village comes from the ancient oaks that grew in the center of the village. It is more likely that the village itself was surrounded by an oak forest. For half a millennium, Dubove was part of several state entities: Austria-Hungary, Czechoslovakia, Carpathian Ukraine, and Ukrainian SSR. It is located 37 km northeast of the district center.

Dubove settlement territorial community is located in the narrow valley of the Teresva River. The surface is elevated, gently undulating, forested, flat, dissected by ravines. Rivers that flow on the territory of the Dubove settlement territorial community: Teresva, Krasnoshurka, Pasichnyi, Vyshnii Dzvur, Nyzhnii Dzvur, Velykyi. In terms of water supply, the Dubove settlement territorial community takes a leading place in the Tiachiv district and has a significant hydropower potential of the district's rivers.

The climate is moderately continental. The average temperature in January is 10-12 degrees, in July it is 25-27 degrees, precipitation is 700-800 mm per year. The settlements of the community are surrounded by low and medium-height mountains. So, the village of Kalyny is surrounded by low mountains (600-700 m above sea level), among them there are Kachulka, Klimbak, and Plesha. The highest mountain in the vicinity is Magura (884 m). The village of Krasna is also surrounded by mountains on all sides: Tempa (1634 m) in the northeast, Apetska (1512 m) in the southeast, Polonyna Krasna (1563 m) in the northwest. The tourist route to Mount Apetska (1511 m) begins from Dubove. Kobyla Mountain (1177m) shields the village from the northern winds.

Since a significant part of the community's territory is occupied by mountains, a characteristic feature of the community's lands is a low percentage of areas suitable for the production of agricultural products. Agricultural development of the territory is 16.5 percent.

In terms of population, Dubove is the largest settlement in the Teresvyan Valley. On the territory of the village there are: 3 schools, 2 preschool education institutions, a cultural center, a general family medicine clinic, a hospital, an emergency medical aid point, 2 gas stations, the Dubove branch of social protection of the population of Tyachiv USZN, Tyachiv district employment center in the Dubove village, Dubove Rehabilitation Department of the Regional Center for Complex Rehabilitation of the Disabled Children, Transcarpathian Machine Building Technical College, Children's School of Arts, Dubove Police Station of the Tyachiv District Police Department, State Fire and Rescue Station. On the territory of the village there are: two hotels: "Fortuna" and "Golden Palace" and three estates "Krasa Karpat", "U Yonka" and "Golden Orsah".

As of 2021, the permanent population in the community is 20709 people, including 9945 village residents, and 10764 rural residents. The population density is 91.7 people per 1 sq. km. The gender structure of the community's population remains characterized by a stable predominance of women. At the beginning of the year, there were 341 more of them than men. There are 970 children of preschool age. The number of children of school age is 4143 people. The number of pensioners is 4874 people. The working-age population is 12513 people, out of which about 1500 people are employed in state institutions. Registered unemployed in Dubove settlement territorial community as of the first half of 2021 is 322 persons. The number of residents of Dubove settlement territorial community who are looking for work as of July 15, 2021, is 734 persons. Average salary is UAH 11743.

On the territory of the community, there are 5 preschools, 6 institutions of general secondary education, as well as the Kalyniv inter-school educational and industrial plant. In addition to educational institutions, the community has two stadiums in the village of Dubove and the village of Kalyny, two cultural centers and four libraries.

Medical care in the community is provided by the “Dubove hospital”, three outpatient clinics of general practice of family medicine, and an emergency medical aid point.

2. LIST OF PUBLIC BUILDINGS OF THE COMMUNITY

General information about buildings.

Table 1 – General information about buildings

№	Name of the building	Address of the building	Year of const-ruction	Floors	General area, m^2	Heating area, m^2	Information about the heat supply source
1	Dubove preschool institution (nursery-kindergarten) No. 2 of the Dubove settlement council	Smt. Dubove, st. D. Podolsky, 7 a	1976	2	1672,3	1386	Electricity 4 boilers 1-ECO 30
2	Dubove preschool education institution of the combined type (nursery-kindergarten) No. 3 "Sonechko" of the Dubove settlement council	Smt. Dubove, st. L.Ukrainky, 4 a	1987	2	612,6	590	Solid fuel boiler
3	Krasnyansk preschool education institution nursery-garden of the Dubove settlement council	S. Krasna, st. Myru, 176	1967	2	183,9	183,9	Solid fuel boiler VIADRUS HERCULES U 22

4	Municipal institution “Inclusive - resource center” of the Dubove settlement council	S. Kalyny, st. Edmund Bachynskyi, 12	2021	1	203,31	174,59	Solid fuel boiler “Nistru”
5	Kalyny interschool resource center of the Dubove settlement council	S. Kalyny, st. Edmund Bachynskyi, 12	1985	2	741	741	Solid fuel boiler “Nistru”
6	Kalyny preschool education institution nursery-kindergarten No. 1 “Kalynka” KT Dubove settlement council	S. Kalyny, st. Shevchenko, 10	1976	1	371,8	371,8	Solid fuel stove
7	Dubove Lyceum of the Dubove Settlement Council	Smt. Dubove, st. Myru, 124	1977	4	3998,6	3998,6	2 solid fuel boilers “Minsk-1”
8	Kalyny branch of the Kalyny lyceum of the Dubove settlement council	S. Kalyny, st. Zaliznychna, 36a	1980	2	802,05	802,05	2 FUNKE solid fuel boilers
9	Kalyny Lyceum of the Dubove settlement council	S. Kalyny, st. J. Lennon, 147	1966	2	1338	1338	2 solid fuel boilers TULA-3
10	Nyzhne Dubove Branch of Dubove Lyceum of Dubove Settlement Council	Smt. Dubove, st. Shevchenko, 139	1947	1	245,94	155,5	Solid fuel stove

11	Dubove gymnasium No. 1 of the Dubove settlement council	Smt. Dubove, st. Physical education, 4	1976	2	2081,8	2081,8	2 solid fuel boilers “Nistu” and “Universal”
12	Krasniansky lyceum of the Dubove settlement council	S. Krasna, st. Myru, 193	1935	2	1755,5	800	2 solid fuel boilers “Nistu” and “Universal”
13	Municipal non-profit enterprise “Dubove hospital” of the Dubove settlement council (hospital)	Smt. Dubove, st. Myru, 131	1970	2	507,5	966	Solid fuel boiler VRS 200
14	Municipal non-commercial enterprise “Dubove Hospital” of the Dubove Settlement Council (Polyclinic)	Smt. Dubove, st. Myru, 131	1982	4	675	2300	Solid fuel boiler VRS 200
15	Communal facility of Kalyny Outpatient clinic of general practice of family medicine of Dubove settlement council	S. Kalyny	1982	4	675	2300	EVNA electric convectors - 2.5/230 C2
16	House of Culture of the Dubove settlement council	Smt. Dubove, st. D.Podolskyi, 32	1982	4	675	2300	EVNA electric convectors - 2.5/230 C2
17	Administration building of Dubove settlement council	Smt. Dubove, st. D. Podolskyi, 46	1982	4	675	2300	Electric boiler ECO 3 12 kW

18	Administration building of the Kalyny village council of the Dubove settlement council	S. Kalyny, st. J. Lennon, 149a	1976	2	2081,8	2081,8	Self-made boiler
19	Administration building of the Krasna village council of the Dubove settlement council	S. Krasna, st. Myru, 203	1976	2	2081,8	2081,8	EVNA electric convectors - 2.5/230 C2
20	Kalyny preschool institution (nursery-kindergarten) No. 2 of the Dubove settlement council	S. Kalyny, st. Zaliznychna, 19	1976	2	2081,8	2081,8	Solid fuel boiler

On the balance sheet of Dubove Territorial Community, there are 26 objects of the budgetary sphere: 5 secondary schools, 6 secondary schools, 1 children's art school, 3 medical institutions, 3 cultural centers, 2 head offices, 2 libraries, 1 dormitory and 1 village council. These buildings are low-rise, the tallest building has four floors. Most of the buildings are two-story. The service life of most buildings is at least 50 years. All the buildings of the institutions need to carry out energy efficiency measures, since during the entire period of operation, thermal modernization measures were not carried out in the buildings, with the exception of replacement of windows and current spot modernizations of heating systems, which in general do not affect the situation.

Consumption of energy resources by buildings

According to the Report on the assessment of the current state and prospects for the implementation of the policy of sustainable energy development in Dubove Territorial Community of Zakarpattia Oblast, which was prepared by "Adamson Service Company" LLC in 2023, there are two types of heat supply sources in buildings: solid fuel and electric. These are mostly solid fuel boilers that consume: firewood, coal, fuel briquettes of various types. In part of the buildings, the source of heat supply is electricity. The boiler houses use outdated boilers with a low efficiency, the auxiliary equipment is low-efficiency and needs modernization. The situation is similar with indoor heat supply and heat transfer systems - they are outdated and need modernization.

Below is information on the consumption of energy resources by buildings.

Table 2 – Energy consumption by buildings

№	Building name	Year	Solid fuel			Electric energy	
			Type	(T; m^3)	Thousand UAH	kWh	Thousand UAH
1	Dubove preschool institution (nursery-kindergarten) No. 2 of the Dubiv settlement council	2021-2022				173905	1023,7
2	Dubove preschool institution of combined type (nursery-kindergarten) No.3 "Sonechko" of Dubove settlement council	2021-2022	Coal	19,41	104,7	38 479	164,9
3	Krasna Preschool Education Nursery-Karden of the Dubove settlement council	2017	Wood	34	20,2	14000	28
		2018	Wood	33	31,5	14000	42
		2019	Wood	33	35,4	15300	47,3
		2020	Wood	34	29,5	20500	56,1

		2021	Wood	33,3	25	21000	38,8
6	Kalyny preschool institution nursery-kindergarten No.1 “Kalynka” of the Dubove settlement council	2021	Wood Coal Brick	43 5,88 4	103	17 042	75
9	Kalyny Lyceum of the Dubove settlement council	2018	Wood Coal	79 102	301,8	79 079	189,2
		2019	Wood Coal	123 78	320,2	93 386	244,7
		2020	Wood Coal	60 131	493,3	99 614	288,9
		2021	Wood Coal	170 163	702,1	65 012	231,4
11	Dubove gymnasium No.1 of the Dubove settlement council	2018	Wood Coal	39 83,7	204,6		
		2019	Wood Coal	39 48	150,7		
		2020	Wood Coal Brick	34 49 22	211,4		
		2021	Wood Coal Brick Pressed wood. Bioen wood	44 79,4 6 13 12,2	414,2	32 636	137,2
20	Kalyny preschool institution (nursery-kindergarten) No.2 of the Dubove settlement council	2021	Coal Brick	8,16 4,44	52	6131	30,6

II. VILKHOVETSKA TERRITORIAL COMMUNITY

1. General description of the community

Vilkhivtsi settlement territorial community is a territorial community in Tiachiv district, Zakarpattia region, Ukraine. The administrative center is the village of Vilkhivtsi. The area of the community is 76.77 km². Vilkhovetska OTG was formed in August 2015 by unification of Vilkhovetska, Vilkhovetska-Lazivska and Dobryanska village councils of Tyachiv district.

The permanent population in the community as of 2020 is 12,473 people. There are 3 preschools and 6 institutions of general secondary education operating on the territory of the community. 1,846 students study in educational institutions. Medical assistance in the community is provided by the Vilkhovetsk-Laziv dispensary.

The community includes 6 settlements: the village of Vilkhivtsi, the village of Vilkhivtsi-lazy, the village of Vilkhivchyk, the village of Dobrenske, the village of Rakove, the village of Sasovo.

Administrative center of the community - village. Vilkhivtsi The first mention of the settlement in historical sources appears in 1486. There are several versions of legends about the origin of the village. How and by whom the village was founded is told by a legend that has remained in the people's memory even today. In the 12th century, during the invasion of the Tatar-Mongol Iga, fearing slavery, a resident of Ternov, nicknamed Husak, escaped from the Mongols and swam across the river and hid in the thick thickets of alder trees on the right bank of the Teresva River. He became the first founder of the village. What is interesting is that this legend has proof - a picture preserved in the church of the village of Ternovo.

The village is located on the highway Tyachiv — Ust-Chorna. The Teresva River flows along the eastern side of the village. A steep hill, 544 m high, rises above the central part of Vilkhivtsi from the western side, from the top of which the village, the valley of the Teresva River, and the surrounding mountains are perfectly visible.

The climate is moderately continental. The average temperature in January is 10-12 degrees, in July it is 25-27 degrees, precipitation is 700-800 mm per year. Population centers communities are surrounded by low and medium-high mountains. So, the village of Kalyny is surrounded by low mountains (600-700 m above sea level), among them are Kachulka, Klimbak, and Plesha. The highest mountain in the vicinity is Magura (884 m). The village of Krasna is also surrounded by mountains on all sides: Tempa (1634 m) in the northeast, Apetska (1512 m) in the southeast, Polonyna Krasna (1563 m) in the northwest. The tourist route to Mount Apetska (1511 m) begins from Dubovoy. Kobyla Mountain (1177m) shields the village from the northern winds.

2. List of public buildings of the community

2.1 General information about buildings

This section summarizes general data on public buildings of the community.

The table below presents this information.

Table 1 – General information about buildings

№	Name of the building	Address of the building	Year of const-ruction	Floors	General area, m^2	Heating area, m^2	Information about the heat supply source
1	Starostat (village council) of the village of Dobrianske	80 Narodna str., Dobrianske village, Zakarpattia region	1980	2	474,2	275,4	Solid fuel boiler Viadrrus U22D
2	Village club, Vilkhivtsi village council	134 Narodna str., Dobrianske village, Zakarpattia region	1959	1	270,0	270,0	absent
3	Vilkhivtsi village council	118 Tsentralna str., Vilkhivtsi village, Zakarpattia region	1973	2	459,9	371,2	Solid fuel boiler "Defro-40"
4	House of Culture of the Vilkhivtsi Village Council	101 Tsentralna str., Vilkhivtsi village, Zakarpattia region	1980	2	203,31	174,59	Solid fuel boiler "Nistru"

5	Vilkhivtsi-Lazy Preschool education institution of the Vilkhivtsi village council	134 Shevchenko str., Vilkhivtsi-Lazy village, Zakarpattia region	1990	2	731,4	332,7	solid fuel boiler ARS “COMFORT”
6	Dobrianske Preschool education institution of the Vilkhivtsi village council	54 Sadykova str., Dobrianske village, Zakarpattia region	1980	2	432,3	415,5	solid fuel boiler MAXITEQ R - F
7	Vilkhivtsi Preschool education institution of the Vilkhivtsi village council	176 Tsentralna str., Vilkhivtsi village, Zakarpattia region	1984	2	1580,2	842,78	solid fuel boiler ARS “COMFORT”
8	Dobrianske Lyceum of the Vilkhivtsi Village Council	5 Makarenko str., Dobrianske village, Zakarpattia region	1991	2	1922,3	1922,3	Gas boiler room
9	Vilkhivtsi-Lazy Lyceum of the Vilkhivtsi village council	156 Shevchenko str., Vilkhivtsi-Lazy village, Zakarpattia region	1989	2	4428,0	4428,0	KZOT solid fuel boiler ARS/BRS 100-1200 BM Comfort
10	Vilkhivtsi Lyceum of the Vilkhivtsi Village Council	59a Tsentralna str., Vilkhivtsi village, Zakarpattia region	1994	3	4980,0	4980,0	Solid fuel steel boiler 630 kW
11	Ambulatory of general practice-family medicine of Vilkhivtsi village council	Закарпатська обл., с. Вільхівчик, 412А	2020	2	859,4	409,2	device electric water heating type DNIPRO

12	Vilkhivtsi Ambulatory of general practice-family medicine of Vilkhivtsi village council	178 Tsentralna str., Vilkhivtsi village, Zakarpattia region	1986	2	551,2	227,8	solid fuel boiler KUM-10
13	Branch of the Vilkhivtsi-Lazy Primary School of the Vilkhivtsi-Lazy Lyceum of the Vilkho Vilkhivtsi vetsk Village Council	129 Shevchenko str., Vilkhivtsi-Lazy village, Zakarpattia region	1987	1	162,7	162,7	Solid fuel boiler Viadrus u22 C/D
14	Branch of the Rakiv Gymnasium of the Vilkhivtsi-Lazy Lyceum of the Vilkhivtsi Village Council	37 Nezalezhnosti str., Rakove village, Zakarpattia region	1982	2	647,0	647,0	2 solid fuel boilers: 1) KZOT BRS 150 Comfort BM BRS 150-00.00.000 PS, 2017; 2) Universal - 6

These community buildings are low-rise, most buildings are two-story. The service life of most buildings is at least 50 years. Also, during this period of operation, thermal modernization measures were not carried out in the buildings, with the exception of replacement of windows and current spot modernizations of heating systems, which in general do not affect the given situation.

2.2 Energy consumption by buildings

There are two types of heat supply sources in buildings, either solid fuel or electric. These are mostly solid fuel boilers. Below is information on the consumption of energy resources by buildings.

Table 2 – Energy consumption by buildings

№	Building name	Year	Solid fuel			Electric energy	
			Type	(T; m³)	Thousand UAH	kWhour	Thousand UAH
1	Starostat (village council) of the village of Dobrianske	2020	Wood	3,5	2,45	–	–
2	Village club, Vilkhivtsi village council	2020	Wood Coal	3,5 9,25	2,45 39,31	–	–
5	Vilkhivtsi-Lazy Preschool education institution of the Vilkhivtsi village council	2020	Wood Coal	7,0 8,3	4,9 35,3		
		2021	Wood Coal	13 4	16,25 17,0		
		2022	Wood Coal	27,5 13	33,0 85,8		
6	Dobrianske Preschool education institution of the Vilkhivtsi village council	2020	Wood	7,0	4,9		
		2021	Wood	10	12,5		
7	Vilkhivtsi Preschool education institution of the Vilkhivtsi village council	2020	Wood Coal	8 26,1	2,45 111,2		
		2021	Wood Coal	26,9 9,66	33,65 37,07		
		2022	Wood Coal	28,1 9,0	33,6 72,0		
8	Branch of the Vilkhivtsi-Lazy Primary School of the Vilkhivtsi-Lazy Lyceum of the Vilkho Vilkhivtsi vetsk Village Council	2020	Wood	3	2,1		

Heat supply of buildings is mainly provided by solid fuel boilers that consume: firewood, coal, fuel briquettes of various types. In part of the buildings, the source of heat supply is electricity. The boiler houses use outdated boilers with a low efficiency, the auxiliary equipment is low-efficiency and needs modernization. The situation is similar with indoor heat supply and heat transfer systems - they are outdated and need modernization.

From the table, it can be concluded that the expenditure on energy resources of buildings increases every year, in the absence of changes in the schedule of use of these buildings to a greater extent (on the contrary, due to Covid-19, quarantines, distance learning - the actual period of use of buildings has decreased). The main reason for this is the increase in tariffs for energy resources.

2.3 Community expenses for payment of energy resources

In this section, a brief comparison of the share of the community's expenditures on energy resources in the general budget of expenditures and its change over recent years is presented.

Table 3 – Comparison of expenditure on energy resources in recent years

Name	Years		
	2020	2021	2022
The total amount of local budget expenditures (general and special funds), thousand UAH.	96482,307	116439,965	77026,903
Total expenses for payment of energy carriers, thousand hryvnias	2159,688	3338,512	3230,712
% of the “energy” budget in the total structure of the community budget	2,24	2,87	4,19

III. KHOLMOK TERRITORIAL COMMUNITY

1. General description of the community

Kholmok settlement territorial community is a territorial community in Ukraine, Zakarpattia Oblast. The administrative center is the town of Kholmok. The area is 76.77 m². Kholmok settlement territorial community was formed in 2019 by merging the Storozhnytsia, Tarnivtsi and Kholmok village councils of Uzhhorod district, Zakarpattia Oblast. The permanent population of the community as of 2020 is 14,333 people. There are 5 preschools and 5 general secondary education institutions on the territory of the community.

The community includes 10 settlements: the village of Kontsovo, the village of Mynai, the village of Korytniany, the village of Storozhnytsia, the village of Shyshlivtsi, and the village of Rozivka, the village of Tarnivtsi, the village of Botfalva, the village of Kinchesh, the village of Kholmok.

The administrative center of the community is the village of Kholmok. Kholmok is a village in the Uzhhorod district of Zakarpattia region. As evidenced by archaeological data, in the VI–XI centuries there were ancient Slavic settlements on the outskirts of the village. The village got its name from the sand dunes on which it arose. In written sources, the village is known as "Homok" or "Holmok", which means "sand" in Hungarian. The first written mention of the village dates back to 1358, when the landowners at that time added the suffix "de homok" to their surname.

The climate is moderately continental. The average temperature in January is 10-12 degrees, in July it is 25-27 degrees, precipitation is 700-800 mm per year. The settlements of the community are surrounded by low and medium-height mountains.

2. List of public buildings of the community

2.1 General information about buildings

This section summarizes general data on public buildings of the community.

Table 1 – General information about buildings

№	Name of the building	Address of the building	Year of construction	Floors	General area, m^2	Heating area, m^2	Information about the heat supply source
1	Kontsovo Lyceum of the Kholmok village council	161 Myru str., Kontsovo village, Zakarpattia region	1990	2	3237	2927	gas boiler room, 4 Thermomax 49.5 kW boilers
2	Mynai branch of the Kontsovo Lyceum of the Kholmok village council	2 Borkaniuk str., Dobrianske village, Zakarpattia region	1885	1	205,0	123	gas boiler house, TERMOTEKA boiler 28 kW
3	Korytniany Lyceum of the Kholmok village council	66G Dukhnovych str., Korytniany village, Zakarpattia region	1981	2	2800	2721	gas boiler room, 2 boilers Colvi 250, 250 kW
4	Storozhnytsia Lyceum of the Kholmok village council	2 Uzhanska str., Storozhnytsia village, Zakarpattia region	1886	1	1309	1081	gas boiler room, 2 Thermomax boilers 40.5 kW, 60 kW
5	Kholmok Gymnasium of the Kholmok village council	12 Kiltseva str., Kholmok village, Zakarpattia region	1953	1	1225	1225	gas boiler room, 2 boilers TERMOMAX 48.9 kW

6	Shyshlivtsi Lyceum of the Kholmok Village Council	2 Istvan Dobo str., Shyshlivtsi village, Zakarpattia region	1991	3	3490	3340	gas boiler room, 3 Ferroli boilers 102 kW
7	Kontsovo Preschool education institution of the Kholmok Village Council	160 Myru str., Kontsovo village, Zakarpattia region	1990	2	563	502	gas boiler room
8	Korytniany Preschool education institution of the Kholmok village council	1 Shevchenko str., Korytniany village, Zakarpattia region	1985	2	833,5	790	gas boiler room
9	Rozivka Preschool education institution of the Kholmok village council	3-A Kontsivska str., Rozivka village, Zakarpattia region	1988	2	833,5	790	gas boiler room
10	Storozhnystia Preschool education institution of the Kholmok village council	29 Uzhanska str., Storozhnytsia village, Zakarpattia region	1975	1	213	195	gas boiler house, boiler Sanier Duval, 30 kW
11	Shyshlivtsi Preschool education institution of the Kholmok village council	3 Istvan Dobo str., Shyshlivtsi village, Zakarpattia region	1991	2	1066	1066	gas boiler room

The buildings in the community are low-rise, most of the buildings are two-story. The service life of most buildings is at least 50 years. Also, during this period of operation, thermal modernization measures were not carried out in the buildings, with the exception of replacement of windows and current spot modernizations of heating systems, which in general do not affect the situation.

2.2 Consumption of energy resources by buildings

Sources of heat supply in buildings are gas. Below is information on the consumption of energy resources by buildings.

Table 2 – Energy consumption by buildings

№	Building name	Year	Solid fuel			Electric energy	
			Type	(T; m³)	Thosand hrn.	kW·hour	Type
1	Kontsovo Lyceum of the Kholmok Village Council	2021 2022	Gas	17159 19939	–	41550 44264	–
2	Mynai branch of the Kontsovo Lyceum of the Kholmok village council	2021 2022	Gas	2427 1226	–	3469 1072	–
3	Korytniany Lyceum of the Kholmok Village Council	2021 2022	Gas	22243 20033	–	25170 24024	–
4	Storozhnytsia Lyceum of the Kholmok Village Council	2021 2022	Gas	7457 6475	–	6977 19446	–
5	Kholmok Gymnasium of the Kholmok Village Council	2021 2022	Gas	12213 8240	–	9817 4847	–
6	Shyshlivtsi Lyceum of the Kholmok Village Council	2021 2022	Gas	17247 15423	–	42499 20868	–
7	Kontsovo Preschool education institution of the Kholmok village council	2021 2022	Gas	9300 6066	–	18861 18861	–
8	Korytniany Preschool education institution of the Kholmok village council	2021 2022	Gas	10032 5738	–	24358 16028	–
9	Rozivka Preschool education institution of the Kholmok village council	2021 2022	Gas	11714 7580	–	24500 15328	–

10	Storozhnystia Preschool education institution of the Kholmok village council	2021 2022	Gas	2553 5674	–	6977 7692	–
11	Shyshlivtsi Preschool education institution of the Kholmok village council	2021 2022	Gas	11466 7726	–	20868 13221	–

Heat supply in the buildings is mainly provided by boiler rooms that consume: gas. The boiler houses use outdated boilers with a low efficiency, the auxiliary equipment is low-efficiency and needs modernization. The situation is similar with indoor heat supply and heat transfer systems - they are outdated and need modernization.

From the table, it can be concluded that the expenditure on energy resources of buildings increases every year, in the absence of changes in the schedule of use of these buildings to a greater extent (on the contrary, due to Covid-19, quarantines, distance learning - the actual period of use of buildings has decreased). The main reason for this is the increase in tariffs for energy resources.

2.3 Community expenses for payment of energy resources

In this section, a brief comparison of the share of the community's expenditures on energy resources in the general budget of expenditures and its change over recent years is shown.

Table 3 – Comparison of expenditure on energy resources in recent years

Name	Years		
	2020	2021	2022
The total amount of local budget expenditures (general and special funds), thousand UAH.		205 229,19	232 029,348
Total expenses for payment of energy carriers, thousand hryvnias		5 774,01	439,76
% of the “energy” budget in the general structure of the community budget		2,81%	3,63

2.4 Emissions of greenhouse gases into the atmosphere by buildings

In addition to the economic component, it is necessary to pay attention to the ecological one. Coal-fired boiler plants have the highest rate of emissions into the atmosphere compared to other sources of heat supply. Below you can find a table of specific emissions according to the Methodology for determining the energy efficiency of buildings, appendix 10 "Factors of primary energy and coefficients of CO_2 greenhouse gas emissions" (hereinafter referred to as "Methodology") and from DSTU B EN 15603:2013 "Energy efficiency of buildings". General energy consumption and energy assessment (EN 15603:2008, IDT).

Table 4 – Coefficients of greenhouse gas emissions

Type of energy resource	Coefficients of CO_2 greenhouse gas emissions, (g/kWh)	
	According to the Methodology	According to the DSTU B EN 15603:2013
Combustible minerals, gaseous (natural gas)	220	277
Combustible minerals, solid (Lignite)	**360**	**433**
Electric energy (mixed)	420	617
Biofuel, solid (chips, firewood)	40	420

It is obvious that the transition to alternative sources of heat supply will improve the climate situation in the region and reduce emissions of greenhouse gases into the atmosphere.

3.4 Proposals for the communities in the medium term

On the basis of the above analysis of legislative requirements, the current situation in the communities and its expectations, it is proposed to develop a medium-term program of sustainable energy development, which will provide for the step-by-step development of a system policy in the areas of sustainable energy development.

The purpose of activities within the program is to ensure the achievement of goals in the field of sustainable energy development in the settlements of the territorial communities, based on the tasks declared in the EU Energy Performance Directive 2010/31/EU (Energy Performance of Buildings Directive), as well as strategic state and regional documents on energy efficiency.

The set of measures planned by the Program will involve a focus on reducing the consumption of traditional types of energy, introducing the use of energy from alternative and renewable sources, and as a result, reducing the amount of greenhouse gas emissions in the community. The measures foreseen for the implementation of this Program in 2023-2027 are designed to lay the foundation for the development of energy efficiency in the community by creating a municipal energy management infrastructure and implementing priority measures to optimize energy consumption in various areas, primarily in the budget one.

The implementation of the Program involves the implementation of measures in 4 directions:

1. Energy management.

2. Increasing public awareness and competence of officials responsible for energy use.

3. Reducing the consumption of traditional types of energy in the residential, budgetary and communal spheres of the communities.

4. Introduction of the use of non-traditional and renewable energy sources.

First of all, within the framework of the Program, the **implementation of energy management in the communities** and daily monitoring of energy consumption in budgetary institutions financed from the village budget is foreseen. For this purpose, it is planned to develop and approve the relevant normative documents, to define the algorithms of the energy management system, as well as to implement specialized information and analytical software.

It is planned to start **regular informational and educational work** with the population and various target groups regarding the need for energy saving. In particular, it is proposed to introduce the tradition of holding annual Energy Days in communities, with the aim of widely familiarizing residents, primarily young people, with modern threats of irrational energy use, practical methods of saving and careful attitude to the environment. The event is planned to be implemented in close cooperation with the executive bodies of the village councils, which implement policy in the field of education and culture.

A strategic task within the program is to **attract funds from the village budget, as well as funds from the budgets** of higher levels and extra-budgetary funds for the implementation of measures in the communities aimed at reducing the consumption of traditional energy resources and introducing the use of energy from alternative and renewable sources. In order to determine the priority of the implementation of measures, it is proposed to conduct an energy audit of buildings characterized by the lowest energy efficiency indicators, in order to identify a list of problems and measures to solve them, as well as further development of the corresponding design and estimate documentation.

During the implementation period of this Program, it is necessary to conduct 100% **production of energy efficiency certificates** for the entire fund of budget buildings (administrative, educational, cultural, medical). The requirement to produce these certificates is dictated by the law of Ukraine "On Energy Efficiency of Buildings". These certificates are necessary at the stage of production of Design and estimate documentation for measures in the field of capital repair and reconstruction of buildings with the involvement of budget funds. In addition, on the basis of certificates, it is planned to deploy one of the components of information and educational work with the population, through their placement in each budget building and demonstration of improvement in energy efficiency indicators after the implementation of measures.

In addition, during the implementation of the program, it will be appropriate to **implement priority measures of a capital nature**, designed to improve the existing system of heat supply of budgetary institutions, taking into account the specifics of the geographical location of the communities, which in turn will make it possible to achieve a significant increase in the efficiency of this system, reduce local budget expenditures and ensure resistance to energy threats.

№	Name of measures	Expected result
1. ENERGY MANAGEMENT		
1.1	Creation and adjustment of the functioning of the energy management system in the communities	- Development of a documentary base for the creation and functioning of the energy management system based on one of the departments of the village council. - Purchase of licensed energy monitoring software for 60 buildings. Training and technical support of the responsible persons (community energy manager).
1.2	Energy inventory of budgetary institutions with the aim of identifying problem areas in the field of energy consumption and developing proposals regarding the order in which measures should be taken	- A report prepared based on the results of the energy inventory. - Proposals for priority planning of measures to improve energy efficiency developed
1.3	Conducting energy audits of budget buildings, which primarily require the implementation of measures to improve energy efficiency	Energy audits conducted in 12 selected institutions (buildings), based on the results of which a report and a package of proposals on measures to increase energy efficiency were formed
1.4	Annual calculation and approval of limits on the consumption of energy resources by budgetary institutions financed from the village budget	Decrees of the village heads "On limits on the consumption of energy resources" prepared for each budget year
1.5	Conducting daily monitoring consumption of energy resources in budget institutions	Collection of data on daily consumption, monthly analysis of compliance with limits
1.6	Production of energy efficiency certificates for budget sector buildings	Energy efficiency certificates produced for a total of 60 buildings with the involvement of specialized contractors
1.7	Development of instructions for the technical staff of budget institutions with the aim of optimizing energy resources	Appropriate instructions developed and implemented by managers and staff of budget institutions

1.8	Conducting information and explanatory discussions with the teams of budget institutions on the subject of the rules of economical use of energy	At least 2 meetings held in each facility (before the beginning of the heating seasons)
2. INCREASING PUBLIC AWARENESS AND COMPETENCE OF OFFICIALS RESPONSIBLE FOR ENERGY USE		
2.1	Placement of printed certificates of energy efficiency in budget buildings	Надруковані і розміщені сертифікати у 60 будівлях
2.2	Systematic presentation of information on the state of implementation of energy saving measures in at least 10 thematic publications during the year to the community for placement on the official resources of the village council	Не менше 10 тематичних публікацій в кожній громаді протягом року
2.3	Conducting days of energy in the community in the format of "energy sports day" in educational institutions	2 annual events conducted. Due to the allocated financial resources, individual energy saving measures financed in the winning institutions
2.4	Carrying out measures to inform the public about possible sources of attracting funds for the implementation of energy efficiency measures in individual and multi-apartment housing stock	Informing the public about the possibilities of the programs "Warm loans", "Energodim", etc., through the publication of information in the mass media and thematic events
3. REDUCING THE CONSUMPTION OF TRADITIONAL TYPES OF ENERGY IN THE RESIDENTIAL, BUDGETARY AND COMMUNAL SPHERES OF THE COMMUNITY		
3.1	Development of design and estimate documentation for measures to increase energy efficiency in individual budget institutions, identified on the basis of energy audits. Funding of activities in accordance with the approved title lists (Appendix 1 to the program), as well as applications for funding from the funds of higher-level budgets and state targeted programs (in particular, the State Regional Development Fund).	The measures provided for in the title lists (Appendix 1 to the program) carried out.

3.2	Assistance to condominiums of the communities regarding participation in the "Energodim" program of the State Energy Efficiency Fund	Facilitation of the creation of condominiums in multi-apartment buildings in the communities by the village councils. Informational and advisory support for interested communities of condominiums
4. INTRODUCTION OF THE USE OF NON-TRADITIONAL AND RENEWABLE ENERGY SOURCES		
4.1	Development of design and estimate documentation for measures to introduce use of alternative and renewable energy sources in individual budget institutions. Funding of activities in accordance with the approved title lists (Appendix 1 to the program), as well as applications for funding from the funds of higher-level budgets and state targeted programs (in particular, the State Regional Development Fund).	The measures provided for in the title lists (Appendix 1 to the program) carried out.

As a pilot project of a capital nature, we, together with the communities administration, considered the decision to introduce a cluster model of heat supply of budgetary institutions based on the use of local raw materials, i.e. solid biomass.

The feasibility of implementing such a project is dictated by the following prerequisites:

- Today, most public institutions of the communities use local boilers as a source of heating;
- Most of the existing boilers in the communities are outdated and in need of renewal;
- The geographical location of the communities facilitates the easiest access to such local raw materials as solid biomass (firewood, wood waste from local enterprises, waste from sanitary cutting of green areas, etc.);
- The communities does not have a single management system for harvesting and logistics of solid biomass.

The total heating area of all budget buildings of the community is almost 18000 m^2, which makes the project economically feasible. The specificity of the community heating system is the complete absence of a centralized scheme. In particular, each of the budget buildings (or a group of buildings located in the immediate vicinity) is heated by its own individual boiler room.

To form a cluster, it is necessary to implement a number of measures:

- to create a firewood and woodchip harvesting unit on the basis of the communal economy of the community:

- to purchase wood-shredding equipment (mobile mechanism and stationary line);
to build a system of buildings for drying and storing wood chips, a conveyor for loading vehicles with wood chips;

- to transport wood chips from the warehouse to each of the objects (boiler rooms of budgetary institutions) using the company's vehicles.

- to create plantations for the cultivation of energy crops on the basis of vacant community land plots that are unsuitable for agricultural and economic development (additional option):

- to prepare land for growing energy willow (approximately 3 x 25 ha);

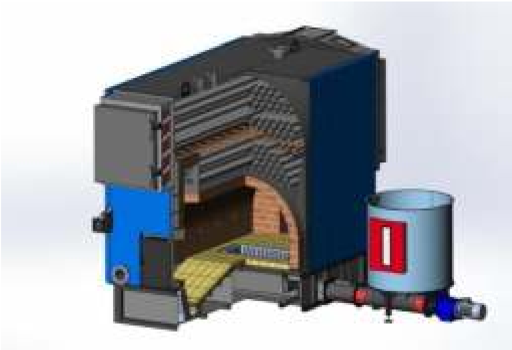
- to purchase saplings, establish plantations, carry out annual work on their care and carry out their pruning every 3 years (with subsequent grinding into wood chips).

- Modernize the existing solid fuel boilers at each of the budget institutions of the 1st stage (the buildings will be selected on the basis of an in-depth study of the current state of the heating system), and if necessary, install new ones.

As a result, a cluster will be created in which the demand will be formed according to the needs of budgetary institutions in solid biomass. This demand will be met by harvesting firewood, processing wood waste into wood chips on the basis of the communal economy, as well as self-grown biomass, i.e. energy willow. A viable and balanced system will be built, which will create prerequisites for joining it with all other budgetary institutions of the community. The experience of implementing such a pilot project can become a model for other similar communities in Zakarpattia.

The basis for the formation of stocks of wood chips in the region is quite diverse and relies on the existing potential, in particular:

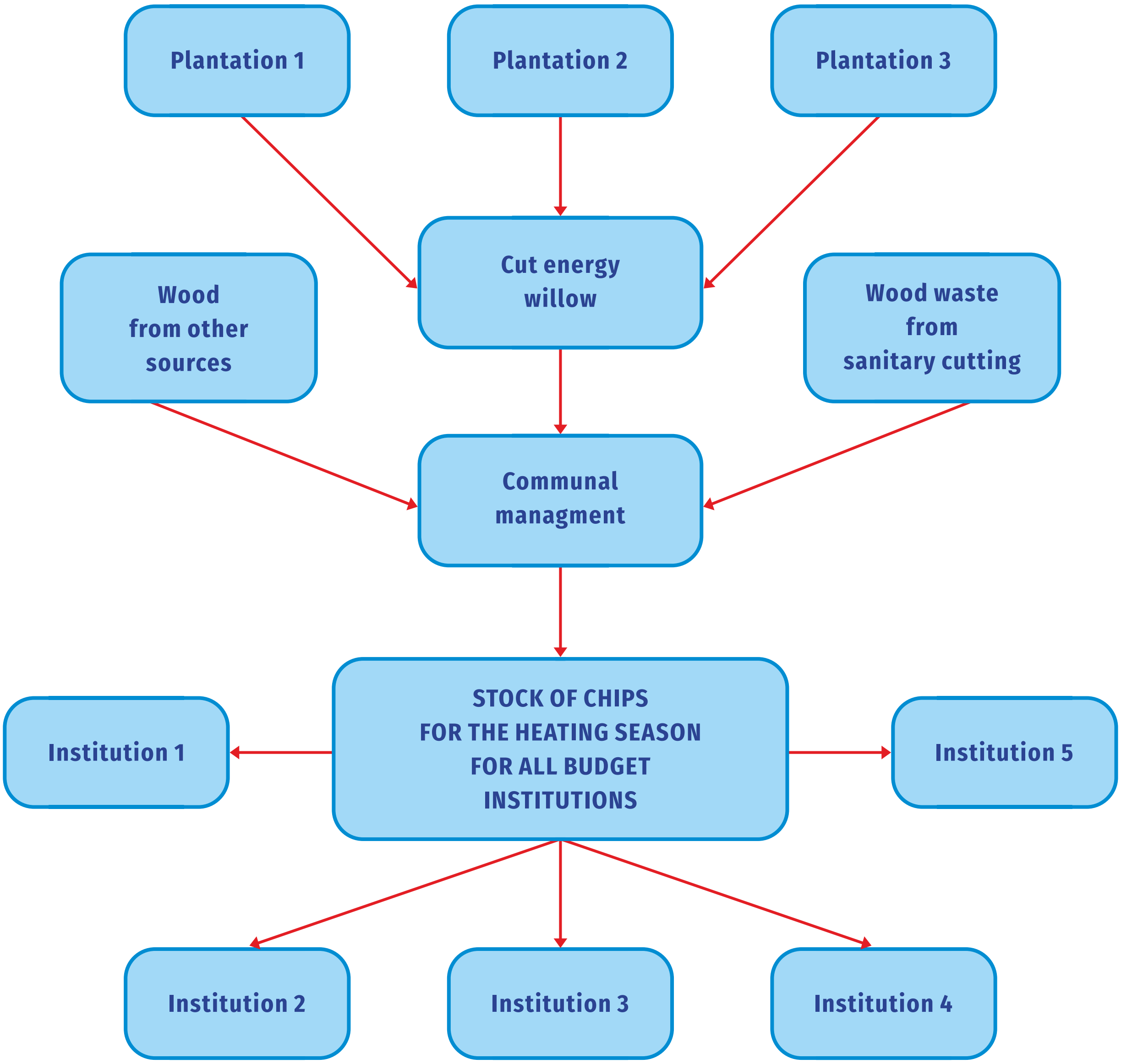
- wood waste from sanitary pruning of green plantations;
- pruning of dry wood from green areas in the community;
- formation of energy willow plantations;
- purchase of wood in forestry;
- procurement of wood processing waste at regional enterprises.



The problem of the lack of a specialized manufacturer and supplier is planned to be solved by introducing the type of activity of gathering, storing and transporting firewood and wood chips for the community's own utility company, which today deals with its beautification.

Taking into account the limited availability of local raw materials, it is planned to establish at least 3 plantations of energy willow, and in 3-4 years to use it as the basis of raw materials for the production of wood chips.

Schematically, the cluster model can be represented in the following scheme:



Selection of technologies and equipment

Based on the analysis of the heating areas of budget institutions and the capacity of the existing boiler equipment, it is possible to estimate the annual need for wood chips is approximately 400 tons.

If the productivity of 1 hectare of an energy willow plantation is 18-22 tons, then the harvest of one 25-hectare plantation will be enough to meet this demand every year. By planting 3 plantations of 25 hectares each, according to the principle that they provide the necessary harvest in turn every year, it is possible to achieve a full supply of wood chips from this source.

By the time the first plantation of energy willow produces a harvest, the supply of wood chips will be formed from wood waste, which the municipal economy will receive from various sources (sanitary pruning, waste from woodworking enterprises, purchased raw materials, etc.) .

In order to increase the productivity of the harvesting process and the efficiency of energy resource use, it is possible to additionally install equipment for the production of wood chips from fuel briquettes.

In order to completely abandon the use of natural gas, it is also advisable to install solar collector systems at individual institutions to ensure hot water supply in the months of the non-heating season.

Under such conditions, the return on investment can be up to 4 years. In addition, the community will receive indisputable benefits in terms of energy independence and the ability to ensure the functioning of the budget sphere in conditions of energy threat.

Conclusions

Based on the analysis, our proposals for territorial communities regarding the development of a local policy of sustainable energy development in the medium term (the next 5 years) include the following steps, which must be included in the local target program:

1. Creation of an energy management system in the community, establishment of daily monitoring and operational control of energy consumption.

2. Conducting in-depth research and energy audits of pilot budgetary institutions for the purpose of identifying priority measures aimed at solving energy problems and increasing the level of energy efficiency.

3. Development of technical and economic justifications and working projects for pilot measures aimed at increasing the energy efficiency of heat supply systems of the budgetary sphere of the community. In particular, detailed calculations for the creation of a cluster model of heat supply. Search for financial resources for the implementation of measures in regional, state and international funds.

4. Creation of the Program for increasing energy efficiency and energy independence of territorial communities.

5. Creation of a financial mechanism in communities to fill a special fund and carry out expenditures in the field of energy efficiency (Regulations on the Energy Independence Fund, where the funds saved on energy carriers from the general fund of the budget of the settlement council will be redirected, as to the special fund of the budget of the settlement council)

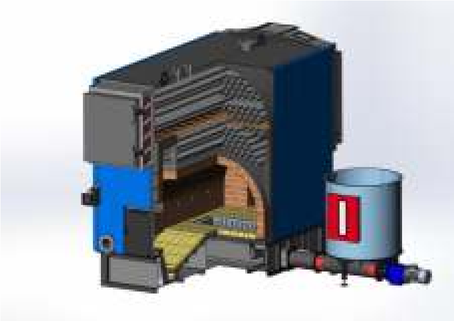
6. The development of SES as a source of RES, since they have become the most common due to the relatively cheap technology, ease of installation, lack of significant impact on the environment during installation and operation (this is the only type of RES, the installation of which does not require an environmental impact assessment procedure), as well as a higher level of insolation than in the neighboring Western Carpathian regions of Ukraine. The development of local networks of solar power generation will gradually replace gas and coal in the production of heat.

Practical example of an energy-efficient solution for the community

Within the framework of this project, we, together with the Dubove territorial community administration, considered a decision to build a boiler house that could provide thermal energy to part of the Dubove community's buildings on the basis of a defunct boiler house and heat supply system (it was never completed more than 30 years ago). The main task was to consider the technical feasibility of implementing such a solution, and estimate the volume of investments for such a project in a first approximation.

The total heating area of all buildings is almost 18 thousand m2. Individual heating point for the heating system is installed in each building for high-quality regulation of the coolant supply. In the buildings of the school, hospital, and kindergarten, Individual heating point is installed for the heating system, as well as for heating the domestic hot water. Heat networks with a total length of 600 m are laid from the boiler house. with partially underground, partially above-ground location of pipelines. It is proposed to install a 2.0 MW boiler room with retort burner water heating boilers, 2 0.5 MW boilers and one 1.0 MW boiler.

Image 1 – A boiler with a retort burner



This distribution of power will make it possible to start consumers in turn, as well as to use the minimum power in the warm period of the year only for heating domestic hot water. The type of fuel for the boiler room is firewood, wood chips, sawdust, wood dust, sunflower husks, pellets, chipboard, MDF, etc. For automatic fuel supply, provide a “Living bottom” fuel warehouse with a scraper conveyor.

Image 2 – Composition of fuel “Live Bottom”

A modular building is used as a building for the boiler house. The construction of a modular building will allow you to quickly build a boiler house of the required size.

Image 3 – Schematic image of the laying of heat networks

In addition to the boiler room, heat pipe and points of entry into the building, this technical solution also includes complex thermal modernization of buildings that will be consumers of this boiler room.

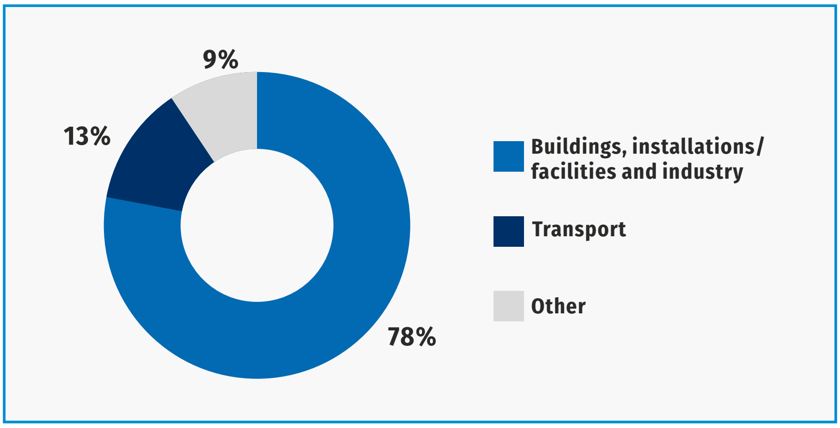
Table 6 – Approximate investments for project implementation

Name of the measure	Approximate volume of investments (first approximation), mln UAH
Modular boiler room	from 15 to 25
Thermal line	from 7 to 12
Comprehensive thermal modernization of the school building	from 55 to 65
Comprehensive thermal modernization of the building of the fire department	from 12 to 14
Comprehensive thermal modernization of the technical school building	from 50 to 62
Comprehensive thermal modernization of the dormitory building	from 48 to 60
Комплексна термомодернізація будівлі лікарня	from 35 to 40
Комплексна термомодернізація будівлі поліклініки	from 30 to 48
Комплексна термомодернізація будівлі харчоблоку	from 5 to 8
Комплексна термомодернізація будівлі закладу дошкільної освіти	from 41 to 51
Вартість проведеня енергоаудитів будівель	from 0,17 to 0,25
Вартість проектно-кошторисних робіт	from 12 to 15
Всього:	**from 310 to 400**

4. BEST ENERGY SOLUTIONS – CONCEPTS FOR PILOT COMMUNITITES IN HUNGARY

4.1 Szabolcs-Szatmár-Bereg County situation report, objectives

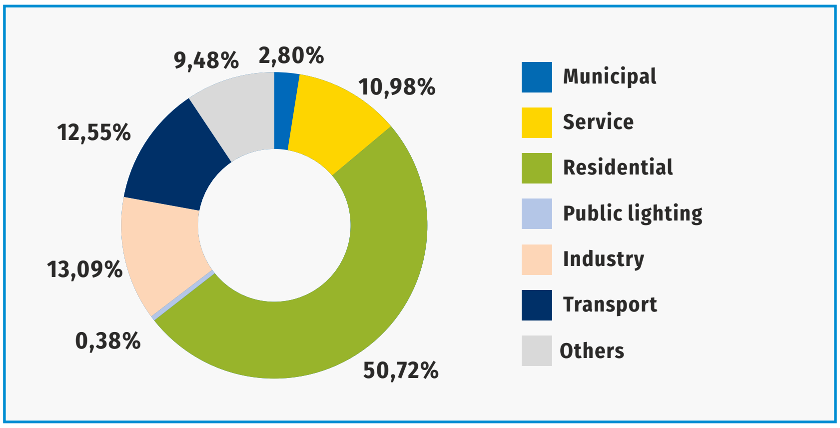
As nationwide, at county level the largest energy consumer is the building stock.



Source: SECAP template calculation result
1 Figures: Final energy consumption (%) by macro-sectors SZSZBC, 2014

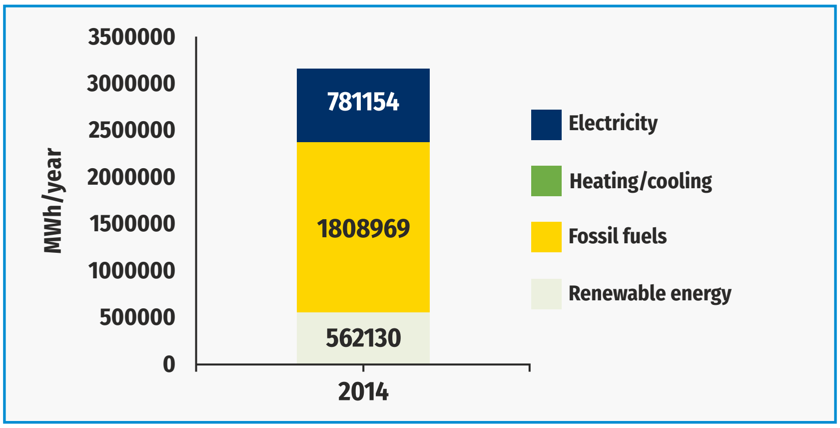
In terms of macro-sectoral groupings, the emission value is in line with final energy consumption, ie "Buildings, equipment / installations" and "Industry" at 78%, "Transport" at 13% and "Other" at 9%. relative to total emissions. As a result of the mitigation measures designated in the SZSZBC SECAP, a reduction of 316,353 t of greenhouse gas emissions in Szabolcs-Szatmár-Bereg county by 2030 can be targeted compared to the 2014 level, thus meeting the 40% CO_2 emission reduction target for the entire county.

The county data on final energy consumption by sector also strengthen the national trend, is the largest energy consumer is the population, which represents 50.72% of total consumption.



Source: SECAP template calculation result
2 Figure: Percentage distribution of final energy consumption by sector SZSZBC, 2014

The share of renewable energy sources in the current energy carriers structure of Szabolcs-Szatmár-Bereg county is still low: it was 17.79% (562,130 MWh) in the base year of the SZSZBC SECAP calculations (2014).



3. Figure: The rate of final energy consumption per energy carrier SZSZBC, 2014

However, in order to ensure the long-term development of the county and to create an attractive county environment, it is important to gradually switch the county's energy supply to renewable and alternative sources. Solar energy, geothermal energy and energy from biomass have significant potential in the region. Based on this, the renewable energy policy is one of the pillars of efficient environmental management in the county, which includes the development of alternative energy production based on county conditions such as solar parks, biomass processing, geothermal energy utilization, modernization of district heating systems at the primary side and building energy modernization, especially for public buildings and housing estates. By using these resources, the county would promote the spread of decentralized, local energy production, thus significantly reducing network losses.

Ensuring quality housing conditions is an essential element for the long-term balanced development of county settlements, one of the important tools of which is to improve energy efficiency. Although a significant number of public institutions - county developments significant for GHG emissions primarily aimed at improving the energy efficiency of municipal community institutions (kindergartens, schools, municipal buildings, other social institutions, etc.) - and panel houses underwent building energy development, most of the housing stock is still in need of outdated, major building energy renovation.

In Szabolcs-Szatmár-Bereg county - according to the Hungarian Central Statistical Office latest survey of housing conditions broken down by counties - almost half of the dwellings were heated with convectors and stoves and the most commonly used fuel was gas and wood. Nearly a quarter of the county’s residential homes were built of adobe and just over 50% of them had total comfort.

Table: Ongoing and planned energy projects, developments SZSZB County – 2030

Measures	Elements of modernization, renovation	Expected energy savings (MWh/yr)	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Building energy renovation of municipally owned and managed buildings	Facade insulation Replacing doors and windows frames Heating system upgrade Use of renewable energy sources + lighting modernization	45 066	20 142	24 315
Complex energy renovation of residential buildings		158 922	131 625	307 394
Енергія модернізація служби будівлі		80 872	33 815	41 353

Table: Ongoing and planned measures, developments SZSZB County
Local electricity generation- 2030

Measures	Elements of the measures	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Solar Parks installation	In areas not used for agricultural and / or forestry purposes or excluded from agricultural cultivation	34 165	12 300
Vertical wind generator installation		9	3
Biomass power plant		926	333
Mobile dwarf hydroelectric power plants	Utilization of the hydropower of the Tisza and Szamos – pilot project	438	158

The implementation of the planned measures will reduce the energy demand for the operation of the buildings affected by the renovation, which will result in a reduction in the use of electricity, natural gas and other energy sources, directly contributing to the reduction of CO2 emissions coming from County. In parallel, the operating costs associated with maintaining the building are reduced.

4.2 Kemecse, Zahony, Tiszalok situation report, objectives

KEMECSE CITY

In addition to the county seat, larger cities such as Kemecse, which is also the district seat, act as regional economic centers.

It is a member of the 13 settlements that make up the Leader Association On the Border of Nyírség and Rétköz: - Berkesz, Beszterec, Demecser, Gégény, Kék, Kemecse, Nyíribrony, Nyírtét, Ramocsaháza, Sényő, Székely, Tiszarád and Vasmegyer.

In line with national and county goals, the city is focusing on renewable energies in energy supply, the utilization of which falls short of opportunities.

Regarding the increase of energy efficiency of municipal buildings, the Municipality of Kemecse has specific, ongoing building energy renovation projects in the area. Good practices, pilot projects:

Kemecse City Hall, Kemecse District Office, Kemecse Family Support Center, Kemecse Health Center, Arany János Primary School energy efficient renovation. (For a detailed description of the projects, see point 6.).

The city of Kemecse contributes to the 2030 goals of the Leader Association, among others, with the above projects:

Table: On the Border of Nyírség and Rétköz Leader Community Ongoing and planned developments – 2030

Measures	Elements of modernization, renovation	Expected energy savings (MWh/yr)	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Building energy renovation of municipally owned and managed buildings	Facade insulation Replacing doors and windows frames Modernization of heating system and lighting systems Utilization of renewable energy: solar energy, biomass and geothermal energy	1322	567	680

Proportion of low comfort flats in the settlement: 25.6%.

Number of electricity and gas consumers of the settlement in relation to the housing stock:

Table: Number of electricity and gas consumers and housing stock in Kemecse, 2017

Number of household electricity consumers (pc)	Number of household gas consumers (pc)	Housing stock (pc)
1686	1095	1673

Table: Planned target values of the applications implemented within the framework of the "Otthon Melege Program" (2014-2018)

Settlement	Number of applications (pc)	Expected energy savings (MWh/yr)	Expected CO_2 reduction (t/yr)
Kemecse	45	13,4	16,34

Within the framework of the "Otthon Melege Program" supporting the increase of energy efficiency affecting the population, all regional settlements received support between 2014 and 2018, a total of 258 applications were implemented. Most of the applications were implemented in Demecser and Kemecse. It is estimated that the highest energy savings can occur in these cities.

With regard to the use of renewable energy sources, the most common type of system among the population is a small household-scale solar power plant.

The relevant data on small household-sized power plants in the settlements of the region are given in the table below:

Table: Data on the expected renewable production of household-scale solar power plant installed in the period 2014-20

Settlement	Installed domestic hot water (pcs)	The maximum amount of energy that can be charged (kVA)	Built-in capacity (kW)	Planned renewable energy production (MWh/year)	Designed Reduction of CO_2 emissions (t/year)
Kemecse	17	120,1	120,1	132,11	47,5596

It is important to encourage energy efficiency measures among the population in the future as well, to support the use of renewable energy sources, as in the region, in line with county and national trends, residential buildings had also the largest residential buildings also had the highest final energy consumption: 78,494,16 MWh, of the total 169,050,207 MWh in the base year of the On the Border of Nyírség and Rétköz Rural Development Association SECAP, 2014.

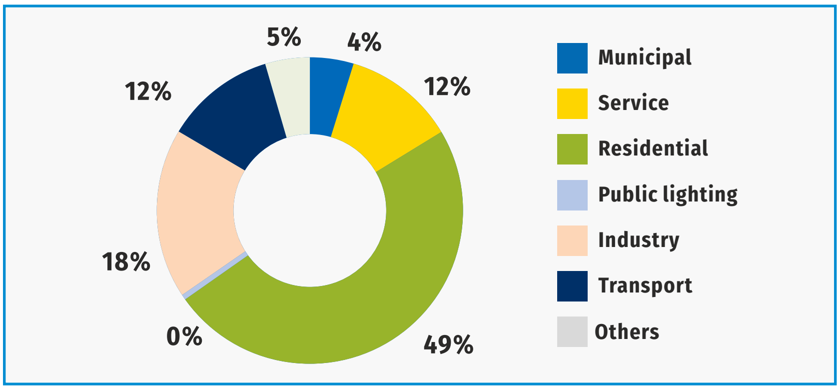
If the current positive trends continue, the achievable energy savings in the residential sector in the area of the On the Border of Nyírség and Rétköz Leader Association by 2030 are expected to be: 18 180 MWh/year, renewable energy production: 7 792 MWh/ year, thus, a total reduction of 9350 t CO_2 emissions is expected.

The increase of the production of renewable energy of enterprises, and for this purpose the support of their use of renewable energy is also important for the fulfilment of the undertaken target values. With the implementation of the proposed developments by 2030 5,289 MWh/year energy savings, 2,266 MWh/year renewable energy production can be forecasted in the area of the Rural Development Association, which can result in a reduction of 2,720 t CO_2 emissions.

ZÁHONY CITY

Member of the Felső - Szabolcs LEADER Community, which currently has four cities: Ajak, Dombrád, Mándok and Záhony, among its 28 settlements members.

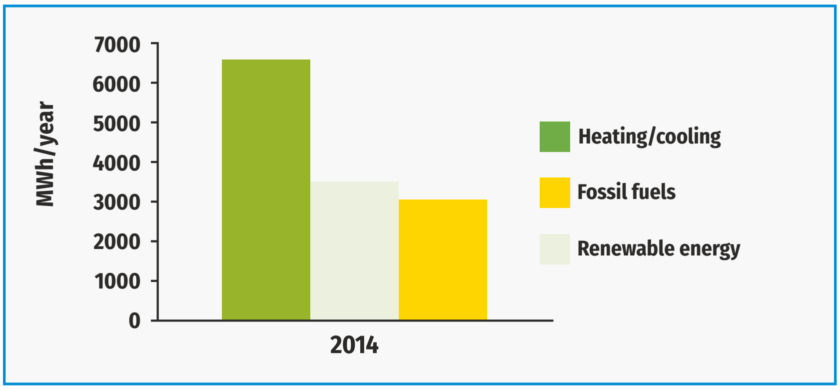
Data on final energy consumption by sector in the region confirm the national and county trend, that the largest energy consumer here is the residential sector with 49% as well.



7 Figure - Percentage distribution of energy consumed in the settlements of the Felső-Szabolcs Rural Development Association per consumer in 2014

One of the most important tasks for Záhony in the coming years is to reduce the external dependence on fossil fuels and to exploit the potential of renewable energy sources and increase energy efficiency. The aims of the city to use alternative energy sources to help restructure energy management in both public institutions and residential buildings. Another goal is to prepare an energy rationalization program based on solar, wind and geothermal energy, and to implement the program as planned.

Owing to the investment, the city's own heating center has also become suitable for the use of renewable energy sources, thus, since 2014, district heating has been using more than 50% renewable energy. The energy used was provided for the heating and cooling of municipal buildings and residential buildings.



7 Figure: Energy consumption of heating / cooling in Záhony (MWh / year), 2014

Future plans include district heating providers to build a 100% renewable energy district heating system. The cornerstone of the system would be the utilization of solar energy through solar collectors.

With this, the city is also taking an important step towards achieving the European Union and domestic goals: moving towards a low-carbon economy.

Regarding the increase of energy efficiency of municipal buildings, the Municipality of Záhony has specific, ongoing building energy renovation projects in the area. Good practices, pilot projects:

Záhony City Hall, Záhony Swimming pool, Záhony Sports complex, Záhony Health Center, Záhony House of Culture energy efficient renovation. (For a detailed description of the projects, see point 6.).

The city of Záhony contributes to the 2030 goals of the Leader Association, among others, with the above projects:

Table: Felső-Szabolcs Leader Community Ongoing and planned developments - 2030

Measures	Elements of modernization, renovation	Expected energy savings (MWh/yr)	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Building energy renovation of municipally owned and managed buildings	Facade insulation Replacing doors and windows frames Modernization of heating and cooling system Utilization of renewable energy: - photovoltaic systems: for electricity generation - solar collector: for the production of domestic hot water - geothermal energy system: for heating - biomass boiler: for heating	3111	1333	1600

Regarding the energy efficiency renovation of residential buildings (mainly family houses), the region has set the following goals by 2030:

Table: Expected results of building energy renovation of residential buildings in the Felső-Szabolcs Leader Community area - 2030

Measures	Expected energy savings (MWh/yr)	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Заохочення заходів із відновлюваної енергетики та енергоефективності в житловому секторі	45111	19333	23200

The increase of the building energy and production of renewable energy of service enterprises and organizations, and for this purpose the support of their use of renewable energy is also important for the fulfilment of the undertaken target values.

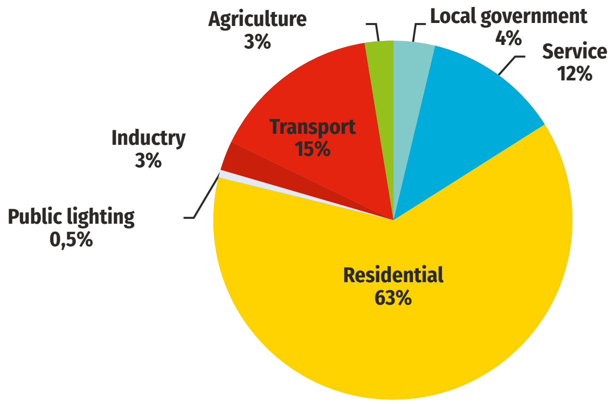
Table: Expected results of building energy renovation of service sector buildings in the Felső-Szabolcs Leader Community area - 2030

Measures	Expected energy savings (MWh/yr)	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Будівельний енергетичний розвиток підприємств	12445	5333	6400

TISZALÖK CITY

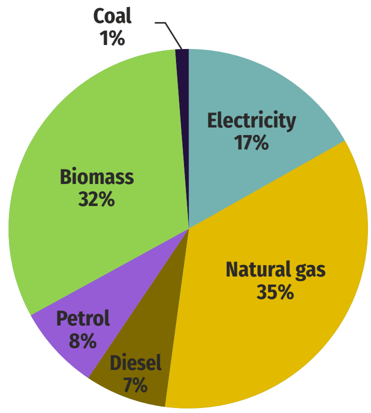
The total energy consumption of Tiszalök was 66,700 MWh in the base year, in 2011.

Concerning final consumers, residential buildings (63%) accounted for the largest share. They were responsible for almost 2/3 of total energy consumption.



9. Figure - Figure - Distribution of total energy consumption of Tiszalök by sector, 2011

Natural gas accounted for 35% of consumption, which mainly met the heat demand of households and public buildings. Biomass (firewood) and coal used mainly for residential heating, accounted for 33% of total energy demand.



9. Figure - Distribution of the total energy consumption of Tiszalök by energy sources, 2011

In terms of data, one of the primary aspects of urban development goals of Tiszalök is to increase energy efficiency (energy efficient building stock) and the use of renewable energy sources, adaptation to climate change (use of alternative energy sources) and use of the latest technologies. In the case of institutions providing public services, energy developments contribute to the reduction of the operating and maintenance costs of the institutions, as well as to the goal of creating a sustainable Green City.

Table: Ongoing and planned developments, Tiszalök - 2030

Measures	Elements of modernization, renovation	Expected energy savings (MWh/yr)	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Building energy renovation of municipally owned and managed buildings	Facade insulation Replacing doors and windows frames Modernization of heating/cooling and lighting systems Utilization of renewable energy: solar panel	250	150	86

Good practices, pilot projects:

Tiszalök Family assistance center, Tiszalök House of Culture, Tiszalök Male and Female House, Tiszalök Aranyalma and Napraforgó Nursery energy efficient renovation. (For a detailed description of the projects, see point 6.).

In 2017, 57% of Tiszalök's total energy consumption was still related to residential buildings. The proportion of buildings to be renovated is very high: 50-60% (97.5% of them are family houses).

Through energy-efficient renovations and investments - between 2019 and 2030 - the city is planning a complex building energy modernization of 25% of family houses and condominiums, which is approximately affects 500 buildings.

Table: Expected results of building energy renovation of residential buildings in Tiszalök - 2030

Measures	Expected energy savings (MWh/yr)	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Encouraging residential renewable and energy efficiency measures	1150	2732	925

It is estimated that buildings in the industrial and service sectors could have a total solar capacity of around 1150 kW by 2030.

With the installation of solar systems on the roofs of the buildings of the two sectors, as well as with the help of heat pump systems, a total of approximately 2000 MWh of renewable energy can be produced annually.

The green electricity produced and the heat recovered can save a total of 480 tonnes of CO_2 emissions per year.

Achieving the 2030 climate targets requires not only intensive energy efficiency measures, but also to replace the city's electricity and gas needs with the largest possible share of renewable energy sources. To achieve this it is worth using as many resources as possible.

It is planned that these power plants will provide almost half of the total emission reductions available by 2030, so their construction is a priority.

Table: Tiszalök - Renewable based local energy production Ongoing and planned developments - 2030

Measures	Elements of the measures	Expected renewable energy production (MWh/yr)	Expected CO_2 reduction (t/yr)
Solar Parks	Power plants with a capacity of a few hundred kW - 1-2 MW	2400	610
Small wind power plants	Wind power plants with a capacity of 50 kW (10 pieces)	2400	245
Biogas plant	One biogas plant can be operated using 70% of the local available agricultural waste of animal origin with a capacity of about 1 MW	2400	1600

2. GENERAL INTERVENTION AND RENOVATION PROPOSALS

The typical renovation elements that can cost-effectively reduce the energy consumption of buildings in Hungary are summarized below. These professional guidelines and technical solutions are used in the preparation of strategy and action plan documents.

2.1 Increasing energy efficiency - typical renovation elements

Improvement of thermal transmittance parameters for building boundaries

An effective way of reducing the energy demand for heating and cooling is to improve the thermal transmittance parameters of building boundaries. In terms of expected energy savings, CO_2 emission reductions and returns44, solutions that meet cost - optimal requirements and those with a lower heat transfer factor have been analysed45. This showed that additional savings are minimal for better performing structures, so that meeting cost-optimal requirements is sufficient for borderlines.

MODERNISATION OF HEATING SYSTEMS

The modernisation of existing heating systems offers multi-level intervention possibilities, ranging from improved controllability to the replacement of the whole system:

- Creating and improving the possibility of regulation: The way in which it can be designed depends on the heating system.
- In the case of home centre and district heating, it is recommended that local housing regulatory units, meters (including smart meters) be installed per dwelling, as well as the possibility of individual regulation and the payment of heating charges on the basis of actual consumption. Otherwise, the user of the building will be less motivated to operate an energy-efficient building.
- In the case of central heating per dwelling, it is recommended that weather-tracking regulation and room-to-room temperature control be developed.
- In the case of individual heating, thermostats may be installed. If individual heat generator-heat take-off devices (e.g. electrical conv.) are provided, it is possible to link the heat take-offs to a system with smart controls, so that the temperature control is more accurate.
- Modernisation of heating system components: The modernisation of the various non-heat generating or heat take-off elements of the systems, e.g. circulating pumps and grid regulation, can often lead to tangible savings through small investments.
- Modernisation of heat emitters: The state-of-the-art heat emitters also ensure adequate thermal comfort in the case of heating medium at lower temperatures and provide the possibility to control the amount of heat.

- Modernisation or replacement of heat producers: Modern heat producers (boilers, heat pumps, convectors) have a significantly higher efficiency than outdated equipment and their operational safety is higher.

- Building a new, more efficient system: If the entire heating system of the building is replaced, it is possible to choose the most optimal equipment for that building. This may include the installation of a new condensing gas boiler and the associated heat take-off system or heat pump. Connection to the district heating system may also result in energy savings in a dense urban environment.Specific solid-fired solutions (e.g. tiles, fireplace) are not recommended due to increasing concentrations of particulate matter due to solid combustion, as well as inefficiencies. For family houses, state-of-the-art biomass or wood gasifier and wood chip boilers may be used.

MODERNISATION OF COOLING AND VENTILATION SYSTEMS

When establishing a ventilation system, account shall be taken of Decree No 7/2006 (V.24.) of the TNM and of the European Union (hereinafter: (EU) Nos46 1253/2014 and 47 1254/2014 on energy saving ventilation systems. State-of-the-art ventilation systems are equipped with regulations according to the user's needs.

PURSUANT TO DECREE NO 7/2006 OF APRIL According to Annex 3 to Decree No/of 24 May of the Minister for Transport and Transport, residential premises shall be provided with a minimum of 0.5 times the air exchange per hour. This was usually ensured by windows with older designs, with the proviso that they were not perfectly closed. Thus, during a heating season, fresh air at an external ambient temperature corresponding to half of the internal airspace was provided to the internal rooms every hour, thereby increasing the heat loss.

The current air-closed windows do not release almost no extraneous air into the inner space. There are several threats to this.

The level of oxygen in the room's air decreases – the well-being of the occupants deteriorates.

The level of carbon dioxide in the inner air is increasing – the well-being of the inhabitant deteriorates.

Pollutants (from furniture, carpets, etc.) are enriched in the inner air.
In the inner air, the humidity (from indoor, cooking, etc.) is enriched – this in turn can cause mould on heat bridges and cold surfaces.

Of course, this can be treated by intermittent ventilation, but the heat loss is increased again.

The solution may consist of the installation of ventilation facilities for dwellings equipped with heat recovery. This device filters the intake fresh air and then passes through a heat recovery and blows into the premises of the apartment. The exhaust fan installed in the same appliance drains the used air from the rooms, transmits its heat in the heat recovery to fresh air and leaves the outside space. The thermal efficiency of these appliances shall be between 80 % and 95 %. Thus, the loss can be between 5 % and 20 %. The fans naturally have an energy consumption, but this energy absorption plus thermal losses is less than it would be possible to enter the outside cold air directly by ventilation. Losses are also reduced by the smart regulator of these devices. In buildings with a “nearly zero” energy level, these installations are indispensable.

Heat pump systems can provide cooling, heating, hot water for domestic use in buildings, as well as providing thermal energy for the operation of ventilation systems.

Specific new Split – multisplit systems are heat pumped and can provide space heating and cooling, and the latest systems are highly efficient.

It is important that equipment is regularly cleaned and maintained, as otherwise their efficiency is reduced and, if not cleaned, they may be harmful to health.

PASSIVE HEAT PROTECTION

Protection against overheating in the summer is also increasing in our country. However, not only mechanical cooling, but also the thermal insulation of building structures and passive and natural heat protection solutions are important for a more pleasant indoor climate in summer. The simplest solution for this in the case of renovations is the installation of external shading structures. Automatic sensor-based smart regulation of shadowing systems improves efficiency and, in the case of existing blinds, such a system may be established ex-post.

MODERNISATION OF LIGHTING

The replacement of light sources and luminaires for state-of-the-art LED-system elements results in perceived energy savings with relatively low investments. For public buildings, the energy demand for lighting is significant and can represent between 25 % and 40 % of the total energy demand. On this basis, the replacement of luminaires – light bulbs could save up to 20 % to 35 % of the total electricity consumption. However, it is important to highlight that in many cases the modernization of lighting has to take place in conjunction with the refurbishment of the electrical network, which is in itself a renovation element with high investment needs, but does not result in significant energy savings.

The presence-sensing control of lighting and the use of smart systems can further reduce energy use.

MODERNISATION OF DOMESTIC HOT WATER PRODUCTION SYSTEM

If electric boilers are used, their efficiency is greatly impaired by their deposition, so their efficiency is improved by regular periodic maintenance. At the same time, the devices currently on the market are more efficient and the replacement of old, obsolete equipment may be recommended. If the hot water is produced by the boiler providing heating, the upgrading can accordingly take place together with the heating system. In multi-family houses, a regulatory centre per apartment can be more efficient in heating and producing domestic hot water. In this unit, the heat meter, the heating regulator and the domestic hot water are also produced locally. In this case, there is no need for a central storage, pipeline network and circulating line.

INSTALLATION OF AN ELECTRICAL POWER GENERATION SYSTEM

The installation of solar panels on the roof surfaces of buildings is widespread and should be supported. In the case of a family house and a small condominium, as well as in the case of public institutions, it is typically possible to install a number of solar panels that are close to or reach the electricity demand of the building. In particular, it is recommended in cases where the heating system is powered by electricity (electric heating or heat pump) or where a high-capacity cooling – ventilation unit is located (e.g. offices, hospitals).

INTELLIGENT BUILDING MANAGEMENT, "SMART BUILDING"

The use of various smart building management solutions, which may cover all technical and household electronics, could result in significant energy savings due to accurate regulation. Systems can often be installed per element (smart thermostat, automatic shielding treatment, etc.) and can also be used in the case of cascading refurbishment.

2.2 RENEWABLE ENERGY SOURCES, CHARACTERISTICS OF MECHANICAL SYSTEMS

Buildings today are almost unthinkable without different building services systems. Most of these have become part of our daily lives that we no longer notice how they work.

There are three ways to reduce energy consumption:

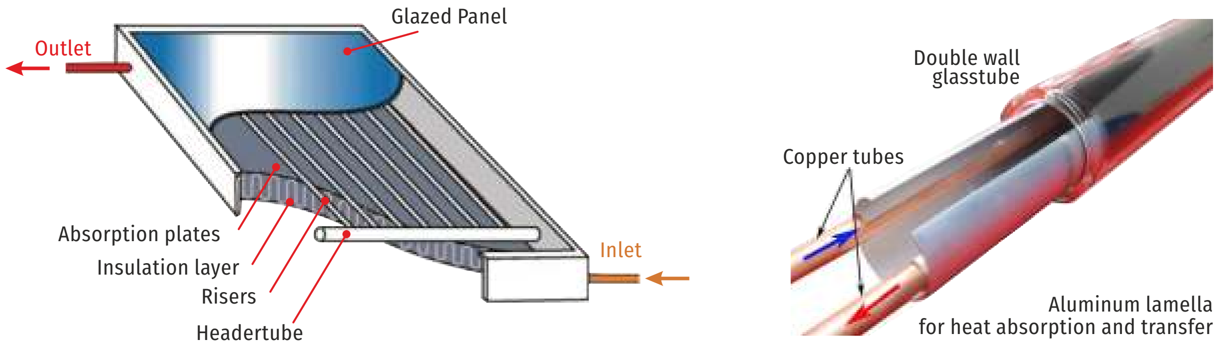
- When designing and building a house, we strive to ensure minimum energy consumption - these are passive solutions.
- We use energy-saving equipment and household appliances, and we also operate them economically and consciously regarding the environment
- We install and use renewable energy sources.

The latter two can be referred as building technology systems. These are not mutually exclusive solutions; the best option is to take advantage of all three options. In the following chapter, we give a short overview of the most common building technical systems.

SOLAR COLLECTOR

Solar collectors/ panels convert the radiant energy of the Sun into thermal energy that can be used to produce hot water and heat in homes. In a simple installation, we can obtain heat energy economically and with good efficiency. The downside is that it produces less energy in winter, when we also want to heat homes with it, and the surplus generated during summer cannot be stored. Otherwise this is referred to as a sizing problem, it is not worth installing more panels than the summer hot water demand because we cannot use the heat energy produced.

The essence of the construction is that the radiant energy is transferred to an antifreeze fluid circulating in a piping system by means of a surface (absorber) with good absorption capacity (absorber). This heats the domestic hot water in the boiler via a heat exchanger. The heating water can also be heated in the same way. Essentially, longer periods without sunshine are to be expected, so auxiliary heating is required in both possibilities. The system efficiency largely depends on how much heat conduction loss can get into the system of a home with the quantity of the absorbed energy.



11. Figure - Structure of the flat plate and vacuum tube collectors (IS-SusCon project - http://howtobuildgreen.eu/)

FLAT PLATE COLLECTOR:

Under the cover glass run liquid-filled tubes that are in close contact with the absorber, which is a dark-surfaced metal (copper or aluminium) for good heat transfer. Below this plane is a thicker thermal insulation layer that prevents the liquid from cooling.

VACUUM TUBE COLLECTOR:

The heat transfer fluid here flows inside a double-walled glass tube (jacketed pipe), and the absorber is located within it. The thermal insulation of this construction is better than for flat plate collectors, therefore, they can efficiently heat water, even in winter cold. Their price is also higher, approx. we can count with an increase of one and a half times as of investment, but the price depends a lot on the particular construction.

Both types convert solar energy with good efficiency, although here efficiency cannot be given as exactly as e.g. for solar cells because it is very dependent on outside temperature, irradiation angle, etc. Some manufacturers promise 80 - 90% efficiency, this is also valid for the optimal case, but depending on the time of day and season, it can go down to 30% (unfortunately, it works with less efficiency in winter, energy-poor times).

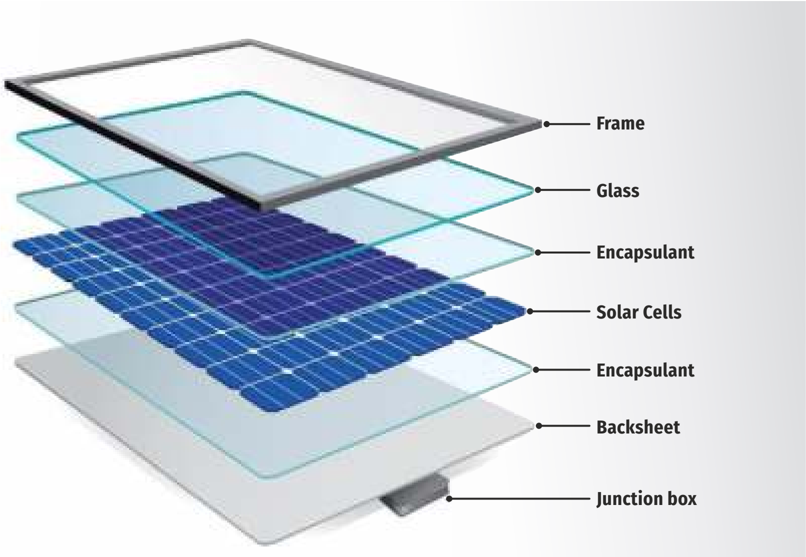
SOLAR PANEL

It produces electricity directly, making it the most popular and researched renewable energy source. Several semiconductor materials are capable of the so-called photovoltaic (PV) effect. Many of them are also available in the market as products, but in practice four varieties are present to a considerable extent.

The important types:

- Monocrystalline silicon (monocrystalline, mc Si), the most efficient (18 - 20%) and also the most expensive. Suitable for use in residential buildings.
- Polycrystalline silicon (poly Si), only a few% less in terms of efficiency and proportionally lower in price.
- Thin-film solar cells: several materials can be used here
- Amorphous silicon (a Si), microcrystalline (μ-Si)

Other semiconductor compounds: cadmium telluride (CdTe), copper-indium diselenide (CIS) and copper indium gallium diselenide (CIGS). Their efficiency can be between 8 and 16%, but eg μ-Si can reach 20%, however, their lifespan is shorter than that of crystalline Si panels. Therefore, they tend to occur in larger solar parks.



12. Figure - Structure ofacrystallineSisolarPVpanel (IS-SusCon project - http://howtobuildgreen.eu/)

ELEMENTS OF THE HOUSEHOLD SOLAR SYSTEM

Panels: The voltage and current that can be obtained from an elementary cell are also very small. Therefore, several are connected in series (strings) and the strings are connected in parallel, from which a separate mounting unit, the panel, is built. The standard size of the panel is 1.5 - 2 m2, weight 17 - 20 kg. The weight is mainly given by the glass and metal frame, the silicon itself is only a few tens of g.

Inverter: The solar cell provides a direct current (DC) of around 30 - 70 V, which is converted by the inverter to the standard 230 V alternating voltage (AC). This is how we can use it for our household appliances and thus export the surplus to the network. Its performance and size must be matched to the performance of the entire system. The inverter is also the central unit of the system, usually including the measuring unit and providing the possibility to access the data remotely.

Measuring meter: If our solar system is connected to the grid, the exported- and imported current must be measured. In many cases, it is also necessary to log at what time of day the feedback occurred.

Battery: The unused generated electricity can be stored in batteries. In a networked system, this is an option but it is essential to use it in island systems.

Fasteners/Fixture: Mechanical elements made of iron or aluminium are required for fastening to the roof. On a flat roof, it comes with a sloping scaffold and concrete weight. All of these should be made of a material that will serve the solar cells for approx. 30 years lifespan.

Usage: The service life is approx. In 30 years, there is almost nothing to do in terms of maintenance with solar panels, possibly sometimes to clean the surface but all in all, there is no environmental impact.

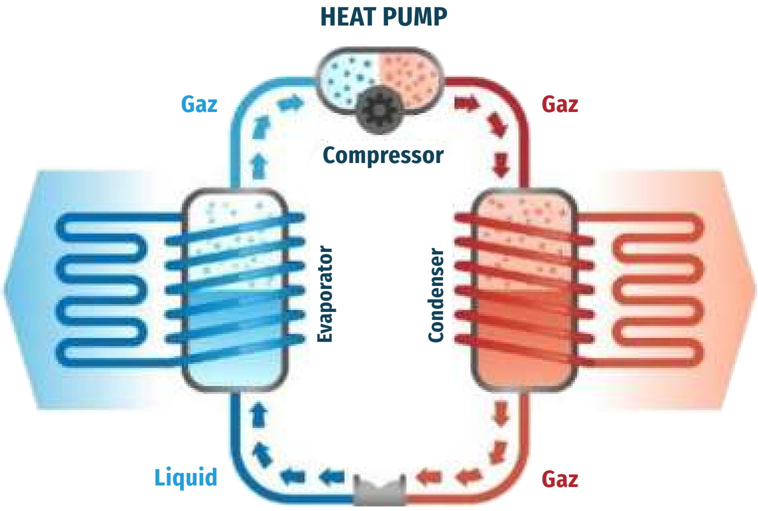
Lifespan: The lifespan of these devices usually does not end with a one-time failure, but rather presents a slow decrease in efficiency. That is half to one percent each year, and when performance drops below 70 to 80 percent, it's worth thinking about replacement, perhaps expansion. Essentially, due to a manufacturing defects or accidents, it occurs that panels are damaged earlier but with a very limited instances. Crystalline Si panels have a life expectancy of 25 to 30 years, while thin-film solar cells have a life expectancy of only 10 to 15 years. Inverters are less long-lived, typically operating for 10 to 15 years. If a battery is included with the system, it may be replaced after 5 to 15 years.

HEAT PUMP

Any machine that extracts heat from a colder place and transports it to a location with higher temperature is called a heat pump. This is how our everyday refrigerator and air conditioners work. When used for heating, heat pump acts as a “reverse” refrigerator: it draws heat from the outside environment and transports it to the inside of the house.

Depending on the design, some heat pumps can only be used for heating but there are also types available that are suitable for cooling in summer and for producing domestic hot water as well.

Several types of heat pumps are distinguished depending on the location of heat removal and its medium. There are three types of heat pumps: air-to-air, water source, and geothermal. They collect heat from the air, water, or ground outside your home and concentrate it for use inside. The most common type of heat pump is the air-source heat pump, which transfers heat between a house and external air.



13. Figure - Schematicofa simple heat pump (IS-SusCon project - http://howtobuildgreen.eu/)

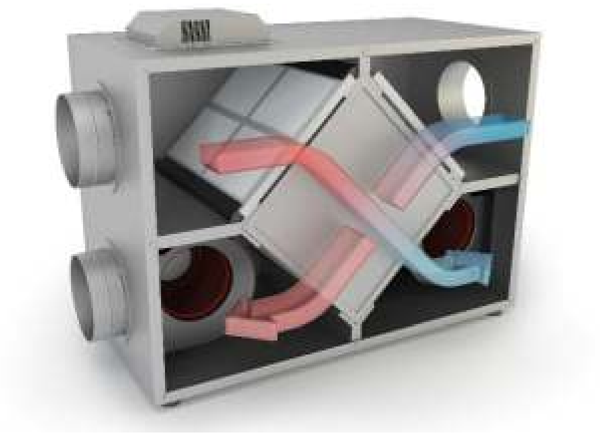
The source of heat can be external air, soil or, if available, even surface waters such as a river or lake. A common feature of water-to-water heat pumps is that they utilize the heat of groundwater or surface water, and the heated medium is also water. Similarly, ground-to-water systems extract heat from the ground and air-to-water heat pumps extract the heat from the outdoor air. The heated medium can be water if the hot water is fed into a central heating system or the temperature can be set directly by blowing hot air in the rooms. In this latter case, we are talking about air-to-air, water-to-air or ground-to-air systems.

VENTILATION

Also, it is well known that nowadays, people spend much more time indoors than in the old days. 90% of the time we spend working, resting and leisure are usually spent indoors, in closed buildings from where we take the air we breathe. Therefore, the quality of the inhaled air has become very important. If a building is not properly ventilated - for example, if the windows are new but not opened frequently – the humidity in the air and the amount of pollutants can increase greatly indoors.

Another argument in favour of mechanical ventilation is the following, by simply opening windows, we are often unable to improve air quality as external air is very polluted. In addition, there are more and more people living with allergic, asthmatic and other respiratory diseases, which also prohibits allowing simply external air of entering to their homes.

One possible way of ventilation is to build an air duct network with a central ventilation system. Ducted systems simply use ductwork. If a home already has a ventilation system or the home will be newly constructed, you might consider this system.



14. Figure - Ventilation system with built-in heat exchanger (IS-SusCon project - http://howtobuildgreen.eu/)

On the other hand, ductless applications require minimal construction as only a hole of three inches is required through the wall to connect the outdoor air vent cover and the indoor ventilator. Ductless systems are often installed in addition, when the ventilation of each room can be created separately.

Simpler, fresh-air mechanical ventilation systems provide only the necessary air exchange and air filtration but result is significant in terms of heat loss in cold weather. For this reason, the so-called energy recovery ventilation (ERV) systems are now often used. These use a heat exchanger to heat the incoming cool fresh air with the warmth of the indoor air, so that their use involves much less heat loss.

2.3 SMART TECHNOLOGIES, SMART BUILDINGS

Today it is unimaginable to have a new or renovated home without any level of automation, electronic monitoring system. Almost every function of the flat has an existing control equipment measuring, and controlling systems that are controlled by an integrated IT and remote monitoring system.

- Tools for energy management
- Thermometers, temperature controllers, switches required to control the heating and cooling system.
- Operation of the renewable energy sources belonging to the house, control of storage and recharge. Smart connectors connected to different consumers, which measure the consumption data of the devices (display, store, transmit) and switch the device on / off based on the received signals.
- Light meters, presence detectors and luminous flux controllers required for the operation of the lighting system.

Essentially, each can be implemented in different stages, from installing a couple of thermometers and heating controlled by those, to using smart meters and transmitting their data to a computer, processing them to control the heating, cooling, ventilation, lighting, shielding and any other functions. By solving all this with the help of the Internet, it can be ensured that residents can also send instructions for operation from a mobile phone, adapting to their current needs.

Among the main benefits of smart buildings are three things:

1. The first among the benefits is optimized energy consumption, so economical operation and maintenance. This can be done because the system can teach and perceive our presence according to our habits.

a) The greatest savings (energy and financial) can be achieved in buildings by **making the heating and cooling** system intelligent, as they use the most energy. Any existing heating / cooling system can be integrated into the intelligent system to be developed. With a coordinated, centrally controlled, condition-dependent, intelligent heating system, up to 40-50% of heating energy can be saved. In the case of a traditionally circulating heating system, large savings can be achieved with space-specific heating control, but this can also be achieved with other systems where heat meters are installed. In a conventional system, we try to control the temperature of all our rooms with a thermostat, so we overheat in one room while we just reach the desired temperature. This issue is not easy to solve even with thermo heads. In addition, with automated heating, it is not mandatory to heat all our rooms at once.

b) In addition to intelligent heating / cooling, the second most important thing to control in real estate is lighting. In addition to saving energy, intelligent lighting control is also very important for convenience. Almost any existing lighting can be connected to intelligent systems: outdoor, indoor lighting, staircase lighting, LED strips, etc.

c) Whether in a house that uses a heat pump, solar collector, solar panel or other alternative energy, it is necessary to control these energy sources. With alternative energy, we can produce heat or electricity, so in most cases there is no gas connection to these buildings. Controlling alternative energy sources is a complex issue that an intelligent automation can solve and thus use these energies more efficiently.

2. Another important aspect is the possibility of comfort functions. Because we can adapt the system to our habits, it is not necessary to intervene personally to turn many functions on / off, because the system executes them automatically. In fact, the system performs pre-taught actions and / or detects our presence and uses them to perform previously taught tasks at the right time. Our building can measure our consumption or even turn off individual clocks or turn off water. If a water leak is detected (consumption other than real life), our system can warn you and stop the water supply. In the event of any other noticeable failure of our building, you may also alert your owner or maintainer. Based on the data, it is easier to determine the problem of our building, and if necessary, we can solve errors and reprogram the system without getting out. Thus, the cost of disembarkation or emergency disembarkation and waiting for a specialist can also be avoided.

3. People have also been concerned about security for a long time. With such a system, you can create safer buildings that you can monitor and control while you are away, using your smartphone, tablet, or computer.

Another great advantage of the smart home system is the measurability, logability and analysability of energy consumption.

15. Figure - Main functions of building automation (https://www.intelligensotthon-tudastar.hu/)

If we look at the environmental impacts, it is expected that the production, continuous operation and, finally, the waste management of many electronic devices, computers will mean significant energy consumption and environmental impact. In contrast, energy savings achieved in the household with these are the same in value. The life cycle analysis carried out on the topic showed that only in the case of the simplest construction can we achieve a load reduction of around 2-3% in the various environmental impact categories. If we build a complete sensor, monitoring and automatic control system, we can expect an increase in the environmental load between 6 and 16%. It improves the negative overall picture a bit with the fact that we are able to manage the operating time of large household consumers with smart systems so that we can smooth out the fluctuations in the load on the power supply system.

This means that during low-load periods of the day, mainly basic power plants operate (e.g. nuclear) with minimal environmental impact, while during peak hours, gas, oil and coal-fired power plants also have to be started up. So, if we can divert the water heating, heat storage stove heating, electric car charging, possibly washing, and washing dishes to the time of the deep valley, it is both environmentally and economically advantageous. Smart systems can solve this with finer tuning, taking advantage of smaller valleys during the day.

Another invaluable benefit of these tools supporting our house's energy management is to better focus our attention on energy conservation. Instead of 1 - 1 electricity and gas bill a year, we can have hundreds of data on our consumption every day. It is worthwhile to analyse these data from time to time, and based on this, to think about how we can operate our home in the most ecological way, based on our way of life and the characteristics of the building.

3.4 OPERATING HABITS

When using the building we can do a lot for sustainability with small actions and a little attention. These are tiny acts in which we don't even think about the connections and consequences behind them.

NATURAL LIGHTNING

It is easy to save on lighting. Take advantage of the possibilities provided by nature regarding lighting. By the windows the necessary lighting is provided in many cases. This can be used well by placing furniture properly. With a little attention, a lot of energy can be saved by avoiding unnecessary use of artificial lighting.

DIRECTIONAL LIGHTNING

Significant savings can be achieved with well-chosen light sources and well-designed lighting. This action is also aimed at reducing the need for equipment and reducing the amount of waste. With controlled lighting and several luminaires directed to the specific work area, we can achieve adequate lighting and more efficient work with significant energy savings. The equipment of the rooms must be carefully designed and the lighting needs must also be taken into account. The design of the electrical network must make it possible to accommodate mobile light sources that meet changing needs. The parts of the rooms for work and study, the tables should be illuminated with direct light of adequate intensity.

NATURAL SHADING

One of the biggest problems in our buildings is keeping away the unwanted solar radiation. Cooling overheated buildings consumes a lot of energy, so it is necessary to keep the rate of mechanical cooling to the lowest possible level. The first step is to properly orient the building. In addition to orientation, there are adequate tools and structures to simply prevent excess sunlight from entering into the building and thus heating the rooms. The vegetation can be beautifully used for shading.

NATURAL VENTILATION

It is easy to save on ventilation. One shall take advantage of the opportunities provided by nature regarding ventilation. In an environment where the air is good, where the users, residents of the building do not need to be particularly protected from health risks, ventilation can be achieved by allowing direct fresh air inside. Ventilation systems with adequate heat recovery are sufficiently energy efficient by using the heat of the exhaust air. In addition, they provide constant, continuous air exchange. It is not a negligible consideration either that suitable filters can be placed in the ventilation system to filter out various pollens and other particles are responsible for allergic diseases.

WATER SAVING

Saving must be achieved through thinking and pre-planned solutions. A lot of water can be saved by paying attention while showering, doing the washing up, washing dishes, cleaning or doing plant care. If possible, no tap water should be used for plant care, such as garden watering. The easiest way to save water in this instance is to collect rainwater. This is not only possible by using rainwater collection tanks in family houses. On a smaller scale, also in multi-apartment houses, there is a solution for collecting rainwater, which can then be used to care plants.

SMART HOMES, CONTROL SYSTEMS

Smart home solutions are becoming more and more wide-spread. By using them, we can plan better the use of our house and apartment and thus our energy consumption. Pre-programmable thermostats have been used for a long time, with their use, heating can be pre-set according to the planned needs. With the help of smart solutions and control systems, not only the temperature and heating can be controlled programmatically, but also the lighting, shading and, if required, the planned operation of household appliances. By pre-planning in such a way, we can save not only time but also a significant amount of energy. With the help of smart home systems, the house can be controlled remotely, thus creating an opportunity to make the necessary changes.

PLANNED MAINTENANCE

If we plan the maintenance of the building, we reduce the damage caused by malfunctions. The first steps to take are presented at the phase of design and construction of the building. The basis of a good building is a floor plan corresponding to the function, proper lighting, a well-planned energy design and the use of modern building engineering systems. In the design phase, it is necessary to select construction products of adequate quality and to accurately determine the expected technical performance. This is the responsibility of the designer. This is one of the essential elements of ensuring good quality. By installing quality construction products, which are suitable for a given function we can ensure that the building gets out of order less often and less maintenance will be required.

A building management manual is needed, which includes a maintenance plan. The inspection cycle of each construction product and building structure can be defined. This can be specified by the designer or the manufacturers of the construction products. The first element of a scheduled maintenance is a routine inspection. For example, the manufacturer specifies in the operation manual of the doors and windows, the frequency of inspection and how they should be handled. Similarly, the manufacturers of the mechanical equipment and fittings provide inspection and maintenance instructions.

Another important element of scheduled maintenance is the prompt correction of failures that occur during an inspection or unexpectedly. By the replacement of a displaced tile, a full-surface soaking can be prevented, which would cause much more damage. Usually, the resident rarely looks at the flat roof insulation; a planned inspection is required.

A failure noticed in time can prevent more serious defects like soaking, wetting of the thermal insulation and thus a decrease in the thermal insulation capacity, and less frequently even damaging the supporting structure could all be prevented.

It is advisable to document the scheduled maintenance in writing, giving the dates of the inspections in tabular form and recording the detected faults, the measures taken and the repairs.

INTELLIGENT BUILDING OPERATION

After the pandemic period, ensuring the health preparedness of public buildings became of paramount importance. In order for the health safety inspection and possible certification of these buildings to be carried out efficiently and quickly, it is necessary to introduce a data collection and information service system. This makes it possible to assess, classify, regularly measure and monitor "performance" of public buildings from the point of view of health safety operation. Furthermore, the data of the examined and classified structures can be continuously summarized in a central database of an epidemic information service and displayed on risk maps, carrying useful decision-supporting information for both decision-makers and users on the health safety classification of buildings, attendance and the need for possible interventions.

Proper efficiency and automation can be supported by the implementation of an intelligent public building management system. By using smart technologies, public buildings and outdoor public infrastructure components (eg public spaces, roads, plumbing, etc.) can be operated more efficiently, with lower resource and input requirements, with lower environmental impact - in a sustainable and epidemiologically safer way.

Such an intelligent system can perform the following main functions:

- Registration and analysis of public building and infrastructure data on a central platform
- GIS support for asset management processes
- Real-time monitoring and optimization of work
- Indoor and outdoor positioning in maintenance
- Development of an intelligent access control system module
- Display and manage data in space and time.

  The system, which is suitable for a wider range of maintenance and operation tasks, also has the following epidemiologically relevant functions:
- Supports compliance with disinfection regulations, planning and quality contro of related work
- Smart public building access: an intelligent module that can be integrated into access control systems ensures gradual access and optimization of distance.
- It can make the accessibility of public buildings, the control and monitoring of access and distance at the city level transparent.

3.5 SITUATION OF PUBLIC BUILDINGS, PROPOSED RENOVATION PACKAGE

Domestic situation of public buildings

Most of the public buildings are owned by the Hungarian State and the local governments and managed by the Hungarian National Trustee Zrt., as well as ecclesiastical or privately owned. The total number of public buildings with a floor area of more than 250 m2 is around 24 000 cca. With heated floor area of 50 million m2. The average final energy consumption of public buildings is 214 kWh / m2 / year. The total final energy consumption of public buildings in 2018 was 39,000 TJ.

The rate of renovation of public buildings can be estimated on the basis of renovation projects financed from EU funds. Between the first quarter of 2015 and 2020, the number of relevant projects funded by the grant was 1,721, based on publicly available data.

As owners and users of public buildings are less likely to have dedicated resources for renovation, renovation of public buildings can almost invariably take place in cases where a grant, other government incentive or financial product for public buildings is available, making them much more important in this sector. Municipalities can apply for a number of domestic and EU energy efficiency sources in the period 2021-27.

In the case of public buildings, the most likely point of intervention is a change in user, a change in the function of the building, or, less frequently, a change in ownership, (change of ownership is less frequent in this sector).

At the same time, a large proportion of the sector can be mobilized through emerging, targeted programs.

Proposed renovation package for public buildings

The proposal is in line with the guidelines set out in the Long-Term Renewal Strategy adopted in 2021. The following suggestions are for general understanding and are intended to increase the energy efficiency of buildings. However, there are other aspects of deep renovation (stability, comfort, aesthetic needs, etc.) that cannot be ignored during the investment planning process.

It is important to emphasize that the renovation of each building must be designed according to its unique characteristics, as different factors - e.g. initial condition, condition of building structures, orientation and location of the building, etc. – greatly influence the applicable and applicable solutions.

In order to preserve and maintain the value of renovated buildings, it is essential that the planned maintenance is carried out during use.

2. Figure – Refurbishment packages for public buildings

PUBLIC BUILDING	
Generally proposed interventions depending on the technical condition of the building	
Thermal insulation	Cost-optimal requirement level
Replacement of windows	Cost-optimal requirement level
Heating system	Upgrading the heating system or installing a new heating system, adjusting the system (depending on the type of heating system)
Passive heat protection	Installation of glazed windows with a shade
Modernisation of lighting	Modernisation of lighting, installation of presence sensor lighting control
Installation of an electrical power generation system	Recommended depending on the location of the building, measured for the electricity consumption of the building
Intelligent building management, "smart building"	Development of a regulatory system, even by element – in the event of the refurbishment of mechanical systems, it is recommended that the widest possible smart control be installed
PROPOSED INTERVENTIONS DEPENDING ON FUNCTION	
Buildings for cultural purposes	
Cooling and ventilation systems	Refurbishment of existing cooling system Construction of a new cooling system (possibly with solar panel system) Refurbishment of existing ventilation system, development of heat-recovery ventilation system Depending on the size of the building, the installation of an air handling system may be recommended
SPORTS BUILDING	
Educational building	
Cooling and ventilation systems	Refurbishment of existing cooling system Construction of a new cooling system (possibly with solar panel system)

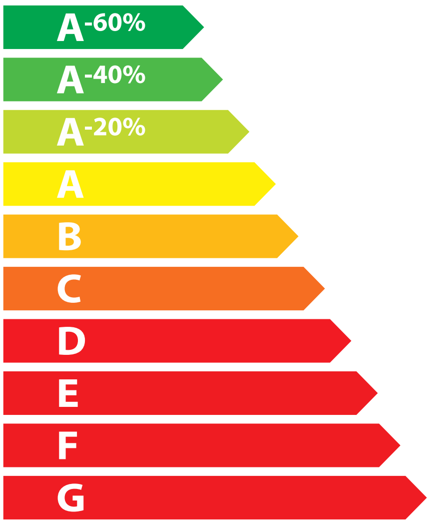
	Refurbishment of existing ventilation system, development of heat-recovery ventilation system Depending on the size of the building, the installation of an air handling system may be recommended
Modernisation of domestic hot water production system	Regular maintenance of boilers or replacement in the event of wear, or, if a heating system provides hot water, refurbishment of the heating system
Health and social building	
Cooling and ventilation systems	Refurbishment of existing cooling system Construction of a new cooling system (possibly with solar panel system) Refurbishment of existing ventilation system, development of heat-recovery ventilation system Depending on the size of the building, the installation of an air handling system may be recommended
Commercial building	
Cooling and ventilation systems	Refurbishment of existing cooling system Construction of a new cooling system (possibly with solar panel system) Refurbishment of existing ventilation system, development of heat-recovery ventilation system Depending on the size of the building, the installation of an air handling system may be recommended
Hospital	
Cooling and ventilation systems	Refurbishment of existing cooling system Construction of a new cooling system (possibly with solar panel system) In the event of refurbishment of an existing ventilation system, installation of a heat-recovery ventilation system Depending on the size of the building, the installation of an air handling system may be recommended
Modernisation of domestic hot water production system	Maintenance and replacement of the hot water production system in the event of deterioration

3. NESICA PROJECT RESULTS, CASE STUDIES

3.1 Purpose and process of building surveys

Within the framework of the project, a total of 15 public buildings were surveyed in Kemecse, Zahony and Tiszalok - the results are included in the Energy Efficiency Studies. There are big differences between properties in terms of size, condition, and energy performance. Many buildings have been renovated and developed; the best examples are presented in this chapter.

An energy certificate is a document that contains the energy performance of a building or an independent unit of destination determined by a calculation method in accordance with the legislation issued on the basis of the authorization of this Act. In fact, it is also a tool that informs about the energy properties of the home as well as suggests energy saving options.



16. Figure - Energy efficiency rating of buildings

The basics of the rating system are described in the annexes to the relevant government decree in accordance with European Union rules. The related detailed system of requirements is currently defined by a Ministerial Decree without Portfolio (TNM) 55. The system of requirements for the energy quality certificate for buildings is set out in Decree 7/2006. (V. 24.) TNM decree, according to which compliance must be supported by the calculation of three indicators:

- The adequacy of the heat transfer coefficients of each boundary structure;
- The adequacy of the specific heat loss of the building, taking into account to surface / volume ratio of the building (or the upper limit of the average heat transfer coefficient of the boundary structures can be calculated from this requirement value);
- Adequacy of the total energy characteristic, the annual rate of the total energy demand of the building (heating, hot water production, ventilation, mechanical cooling, lighting), taking into account the surface / volume ratio of the building.

The purpose of a building evaluation is to check and record the current condition of a building. Based on the parameters of the building survey, the energy certificate can be prepared, which contains all the significant energy characteristics of the building, determines its classification according to energy quality and highlights the possibilities for modernization.

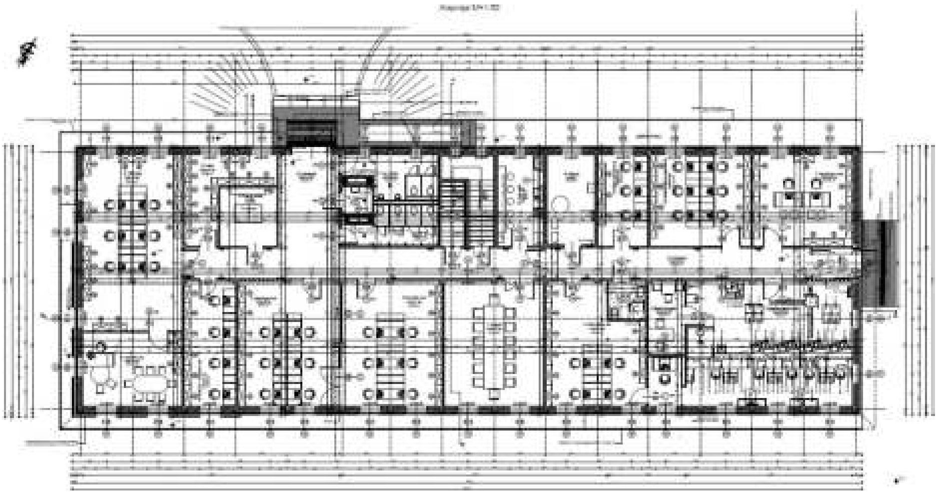
Building assessment steps:

1. Collection and aggregation of energy consumption data (3y)

№	Period	Gaz (m^3)	Electricity (kW)
1	January 2018	5298,00	6067,00
2	February 2018	5298,00	6067,00
3	March 2018	5950,00	5202,00
4	April 2018	824,00	5202,00
5	May 2018	291,00	5202,00
6	June 2018	154,00	5202,00
7	July 2018	3,00	5202,00
8	August 2018	1,00	23380,00
9	September 2018	192,00	3995,00
10	October 2018	1002,00	4128,00
11	November 2018	3930,00	3995,00
12	December 2018	4593,00	4128,00

17. Figure - NESICA project energy data

2. Collection of architectural, mechanical plans and other relevant documentation, preparation of an on-site assessment by analysis of available plans, images, energy consumption data and preparation of data recording templates.



18. Figure - NESICA project building floor plan

3. Recording the parameters of the building in the template and digital photographs (exterior and interior spaces, mechanical system, doors and windows, luminaires and layer order) during a personal, on-site assessment.

19. Figure - NESICA project building survey images

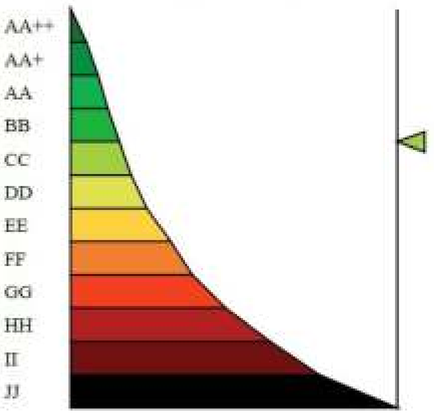
4. Calculate the size of the cooling surfaces for all layers.

Direction	Name	Type	Length	Height	Surface	Piece	Number of windows	Surface of windows	Surface of doors	Net wall	Brut wall
Ground llevel											
North											
Pool	2*12 mm ck lap 8 cm EPS	0,1	44,85	2,85	127,8225		0	0	0	66,915	127,8225
	wall	0,15		2,85		1					
	window						28	60,48			
	window							0			
Main building	brick 30	38	12,42	2,8	34,776		0	0		19,3839	34,776
	wall	0,13		2,8		1					
	window						9	9			
	door						1	5,9929			
	Üvegfal (szélfogó	0,1	1,7	2,7	4,59		0	0	0	4,59	4,59
	válaszfal	0		2,85		1					
	ablak						0	0			
	ablak							0			

20. Figure - NESICA project cooling surface calculation

5. Record all data in WinWatt program and create energy certificate.

Az épület(rész) fajlagos primer energiafogyasztása:	100.97 kWh/m²a
Követelményérték (viszonyítási alap):	100.00 kWh/m²a
Az épület(rész) energetikai jellemzője a követelményértékre vonatkoztatva:	101.00 %
Energetikai minőség szerinti besorolás:	**CC** (Korszerű)



21. Figure - NESICA project energy certificate

3.2 BUILDINGS ASSESSED IN THE NESICA PROJECT

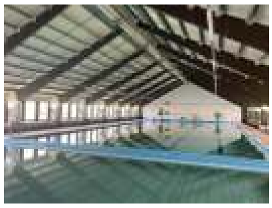
Within the framework of the project, 5-5 selected public buildings per city were assessed in Kemecse, Záhony and Tiszalök settlements. The results were documented in the form of energy certificates and energy efficiency studies.

During the project, the following building districts will be assessed and evaluated:

- **Kemecse**
  - Arany Janos Primary School
  - Nursery
  - Medical Complex
  - District Office
  - City Hall
- **Tiszalok**
  - Aranyalma kindergarten
  - Family Support Center and Nursing Home
  - Girls College
  - Boy College
  - House of Culture
  - Sunflower Nursery
- **Zahony**
  - Medical Center
  - House of Culture
  - Municipal Office
  - Sports Complex
  - Swimming pool

The table below shows the exemplary energy efficiency solutions identified in the assessments.

3. Figure - Parameters of buildings assessed in the NESICA project

TECHNOLOGICAL SOLUTION	MAIN PARAMETERS	PHOTOGRAPHIC DOCUMENTATION
Water-to-water heat pump (WPF 66)	• 67.1 kW heating capacity • High flow temperature for radiators • Integrated heating and electricity consumption meters • Units for cascade control (2 units in parallel) • Possibility to prepare domestic hot water • Efficiency: 4.95 SCOP	 
Solar system	• 30.25 kW power • 110 polycrystalline panels • 2 inverters	 
Heat recovery ventilation system	• 8000 m3 / h capacity • 3.5 kW motor	 

Air-to-air heat pump	• Power: 1-4 kW capacity • Function: cooling and heating • Efficiency: 3.8 COP	 
Other technological solutions	• Lighting system connected to motion sensors • Smart thermostat • Automatic night heating control • Smart radiator thermostat • Automatic shading system	 

3.3 ACTION PLAN

The table below shows the results of the building surveys carried out under the NESICA project;

Energy rating: The energy ratings show the expected, estimated energy demand of the property. Possible energy rating classes range from "AA ++" to "JJ". Only the properties with the highest energy efficiency can receive the best "minimum energy demand" rating. The worst classes (II, JJ) are typically given to severely obsolete, highly energy-wasting destination units.

Primary energy consumption: the energy consumption per unit area of a given building, calculated for 1 year, in terms of the primary value of energy carriers, expressed in fossil energy, per square meter.

Modernization proposals: the energy saving measures proposed on the basis of the initial state and the energy data, ie what interventions need to be made in the building to achieve the BB rating level achievable by implementing the proposals.

With the combined, professional implementation of the energy efficiency measures in the table, the achievable rating can be BB (close to zero), in the case of Primary School, even AA (better than the requirement of nearly zero energy demand).

Figure – Action plan summary table

Building name	Current energy rating	Primary energy consumption	Modernization proposals
KEMECSE			
Nursery	DD (approximately modern)	131,94 kWh/m^{2}a	Solar system External shielding Air conditioning equipment
Medical Center	DD (approximately modern)	135,83 kWh/m^{2}a	External thermal insulation External shielding Air conditioning equipment
Primary schools	BB (near zero)	43,00 kWh/m^{2}a	Heat pump heating system External shielding Air conditioning equipment
District office	CC (modern)	100,97 kWh/m^{2}a	Solar system
City Hall	CC (modern)	100,97 kWh/m^{2}a	Solar system

TISZALÖK			
Family support Center	HH (waek)	295,69 kWh/m²a	Heating system upgrade External thermal insulation Replacement of external doors and windows Solar system
Golden apple Kindergarten	HH (waek)	272,01 kWh/m²a	Heating system upgrade External thermal insulation Replacement of external doors and windows Solar system
Teleki Blanka College	FF (avarage)	175,58 kWh/m²a	Thermal insulation of ceilings and facades Solar system
Community Center	EE (better than average)	155,78 kWh/m²a	Heating system upgrade External thermal insulation Replacement of external doors and windows Solar system
Sunflower Nursery	GG (approaching average)	245,15 kWh/m²a	Heating system upgrade External thermal insulation Replacement of external doors and windows Solar system

ZÁHONY			
Medical Center	CC (modern)	108,12 kWh/m²a	Thermal insulation of ceilings and facades
Swimming pool	CC (modern)	90,00 kWh/m²a	Replacement of lightweight facade walls Replacement of external doors and windows
Community House	CC (modern)	175,58 kWh/m²a	Not definable - currently under renovation
Municipal Office	CC (modern)	100,00 kWh/m²a	Thermal insulation of ceilings and facades
Sports Center	CC (modern)	131,92 kWh/m²a	Thermal insulation of ceilings and facades

5. BEST ENERGY SOLUTIONS – CONCEPTS FOR PILOT COMMUNITIES IN ROMANIA

5.1 LITENI COMMUNITY

I. General presentation. Current situation and challenges.

The Liteni town is located at a distance of 28 km from the county seat, the municipality of Suceava and at a distance of 30-40 km from the municipalities of Botoșani, Fălticeni and Pașcani, in the central-eastern part of the Suceava Plateau, in the depression of the same name, at the confluence the river Suceava with Siret. Liteni is part of the North-East development region, this being the largest development region of Romania in terms of the number of inhabitants and the area owned.

From an administrative point of view, the Liteni town (https://primaria-liteni.ro/) is bordered by the communes of Udești and Fântânele to the north, by the communes of Vorona and Tudora from Botoșani county, to the east, below the Dolhasca town and the commune of Dolhești, and to the west Vulturești commune. In 2020, the population of the Liteni town amounted to 10,292 inhabitants, increasing by approximately 0.029% compared to 2019, and decreasing compared to 2018 by approximately 0.077%. The Liteni town is included in the list of urban localities with the highest values of this indicator, namely 142 places/km2. This indicator shows a value higher than the average of the North-East development region of 107.7 places/km2 and the density at the level of Suceava county of 88.8 inhabitants/km2. The altitude is between 235 meters, downstream at the confluence of the Suceava river with the Siret river and 493 meters in the Pleşa hill.


Climatically, the Liteni town is located in the continental climatic province, the hill climate type, the subtype of the hills in the eastern Carpathians with shades of accentuated continentalism. The average annual temperature is between 80 - 90C. The average of the first autumn frost is October 16, and the last spring frost is April 16. However, sometimes the first frosts occur in September, and the last in the third decade of April. Precipitation, the multiannual average is 567.7 mm/year. The highest average monthly amounts fall in the summer months of June and July. The lowest average monthly amount in January and February. The average annual number of days with precipitation in the form of rain is 85. The first precipitation in the form of snow falls from the second half of November to the end of March.

The **prevailing winds**, with an increased frequency, are those from the northwest 40%, followed by those from the southeast 15% and from the south, southwest – 12%. The valley of the Suceava river, which is oriented in the same direction as the air is channeled, also contributes to the accentuation of the northwest direction. The average wind speed is 3.7 m/s. The average duration of sunshine registers an average number of 1862 hours. The average number of clear days reaches 115.

The hydrographic network. As a result of the geographical position, at the confluence of two large rivers Siretul and Suceava, the relief and the local climatic conditions, the territory of the region contains in its landscape an appreciable amount of water stored in water tables and the hydrographic network. All the waters within the radius of the locality, directly or indirectly, are tributaries of the Siret river. The total length of the network is 117.8 km. The hydrographic network is fed by rain and underground. The total liquid flow of the rivers is approximately 38 mc/s, the Siret with 20 mc/s, the Suceava with 17.5 mc/s. Outside the network of rivers with permanent flow there are numerous torrential elements and streams with temporary flow. The swamps and ponds total an area of approximately 25 ha, most of them being along the Siret, Suceava and Şomuzul Mic rivers.

Energy resources. According to the "Study regarding the evaluation of the current energy potential of renewable energy sources in Romania (solar, wind, biomass, microhydro, geothermal), identifying the best locations for the development of investments in the production of non-conventional electricity", the North-East Region of Romania has of important potential in the production of solar energy, wind energy, biomass and hydropower. Suceava County is located, according to the provisions of the Solar Map of Romania, in solar radiation zone III (1,250 – 1,300 kWh/m2/year), thus being a suitable area for the retention of solar energy and for the implementation of ecological energy production measures.

At the level of the Liteni town, renewable energy production sources can be exploited taking into account the fact that there are different types of renewable resources available for use and the fact that the energy production from these resources varies in different periods of the year, depending on the weather conditions. The main renewable sources that can be used for energy production are represented by: solar energy, wind energy and biomass.

The positioning of the Liteni town in a depressed, plateau area determines a high wind energy potential, the investment in this sector representing the optimal solution for the decentralization of energy production sources.

Biomass is a promising renewable source of energy for the Liteni town, both from the point of view of potential and from the point of view of use, the town having a high energy potential of biomass, 20.21% of the total area being covered by forests.

Taking into account the high hydrographic potential of the Siret River, an opportunity at the local level is the construction of hydropower plants, either private or in public-private partnership, in view of the production of energy from renewable sources.

Thermal energy supply of the Liteni town

As a result of the lack of a centralized system to ensure the supply of heat energy to the homes, the population uses individual heat energy production systems based on solid fuels. The residents of Liteni also have access to wood fuel, 22.70 % of the total area of the town being covered with forests. However, the forest fund does not ensure the energy needs of the inhabitants, as it is necessary to supply wood from the mountain areas.

Considering the predominantly agricultural character of the Liteni town, the utilization of biomass could constitute a viable source of providing thermal energy through the use of pellets, briquettes from agricultural waste and plant residues, with minimal emissions in the environment, but with a significant caloric power.

In order to increase energy efficiency and ensure a minimum consumption of resources, the local public administration must also focus on the use of renewable thermal energy (solar, wind etc.). The local authorities intend to use alternative sources of energy, namely photovoltaic panels for public lighting and solar panels, thus saving the public budget, thus protecting exhaustible resources.

The electricity supply of the Liteni town

In Liteni town, electricity is supplied to homes through the centralized network, which provides access to a number of 3.721 homes, the degree of coverage being 98.5 %. Analyzing the evolution of the total number of homes that have access to the electricity network, an increase of 4.68 % in 2021 compared to 2011 can be seen.

№	Description	2011	Year 2011 / total	2021	Year 2011 / total
1	Number of homes with access to the electricity network	3,416	94,9 %	3,721	98,5 %
2	Total number of housing units	**3,601**	–	**3,778**	–

The methane gas supply of the Liteni town

In the Liteni town, there are no centralized heating energy supply services, the citizens opting for home heating options on their own, based on gas, solid fuel and electricity, through their own boilers or stoves.

Public buildings in the Liteni town

The education infrastructure in the Liteni town consists of two school units: I. V. Liteanu Technological High School and Rotunda Secondary School. The technological high school has in its composition all levels of education: preschool, primary, gymnasium, and professional having school units in Liteni, Roșcani, Siliștea and Corni, and the Rotunda School has in its composition the following levels of education: primary, gymnasium and professional.

The composition of the educational units is as follows: 4 secondary schools through which the 6 kindergartens with a normal program and the primary school also operate, 1 kindergarten with a normal program that functions as an independent unit and a high school.

Physical condition of buildings

Currently, Rotunda High School No. 1 is being rehabilitated, the modernization works have begun, which consist in the construction of a new classroom, the construction of indoor toilets, with water and sewage, the construction of a thermal plant, the restoration of the roof, thermal insulation, the restoration of the electrical installation, etc.

The general school in Siliștea benefited from an improvement in the state of the infrastructure through rehabilitation works and expansion of the building with 436.35 m2 representing five classrooms, sanitary groups and a thermal plant. The investments were put into use at the end of 2015, its total cost being 1,419,521.80 lei, of which 1,085,345.10 lei represented the aid received from the European Union.

Regarding the I. V. Liteanu Technological High School, the first rehabilitation was carried out on building A in 2015 through a project whose total cost was 1,419,521.80 lei, of which 1,085,345.10 lei represented the aid received from the EU side, resulting in the improvement of the education infrastructure by ensuring sanitary, thermal comfort and environmental conditions. In 2018, a project was started to develop and equip the operational infrastructure of the technological high school, which results in a new building body, intended exclusively for technical and professional education, and a new building body properly equipped for carrying out the educational process at the high school level, specific to the technical profile and professional, the total value of the project being 6,368,306.97 lei, being financed by the Nord-Est ADR.

For the rehabilitation of educational units, in 2020 a series of projects were approved with funds through the National Local Development Program, such as:

- Rehabilitation of the Kindergarten in Corni village, Liteni town, in the amount of 444,966.00 lei;
- Rehabilitation of the Rotunda School, in the amount of 457,943.00 lei;
- Building and equipping the kindergarten with an extended program in the Liteni town in the amount of 4,828,454.00 lei;
- Connecting to the water supply system and rehabilitating the School in Corni village, Liteni town, Suceava county, in the amount of 830,685.00 lei;
- The rehabilitation and modernization of the kindergarten in building B of the I. V. Liteanu Technological High School in the Liteni town, Suceava county, in the amount of 472,502.00 lei;
- Rehabilitation and modernization of Roșcani kindergarten, Liteni town, Suceava county, in the amount of 765,405.00 lei;
- Rehabilitation and modernization of Roșcani secondary school, Liteni town, Suceava county, in the amount of 2,045,622.00 lei;
- Rehabilitation and modernization of the existing building at the Rotunda School (Poiana), in the amount of 587,494.00 lei.

Following a SWOT analysis, insufficient use of alternative forms of electricity production was also identified. One of the priority areas in the development plan refers to the protection of the environment and the increase of energy efficiency.

The measures associated with this area are:

1. Exploitation of natural potential in order to capitalize on renewable energy;
2. Campaigns to educate the population regarding responsible energy consumption.

A series of opportunities for the local community emerge from the SWOT analysis:

- accessing non-refundable funds for investing in technologies that use renewable energies;
- the introduction of renewable energy sources (photovoltaic panels, hydropower power plants, etc.);
- investment in thermal rehabilitation of buildings;
- the use of alternative forms of energy production;
- running programs to educate the local community in order to capitalize on environmental factors and natural resources;
- funds available from European or national sources to support environmental projects; making investments for the selective sorting of waste.

The following actions are part of the socio-economic development strategy, the 2021-2027 action plan:

- encouraging the installation and use of alternative solutions for the production of electricity - solar panels by public institutions and the population;
- adaptation of the street lighting system in view of the use of energy from renewable sources in order to partially cover the energy supply from the network;
- encouraging the rational consumption of energy in public institutions (information campaigns, installation of economic light bulbs, implementation of systems that produce energy from renewable sources, introduction of automatic energy consumption management systems).

Implementation of measures to increase energy efficiency in the Liteni town

The Liteni town has made progress in recent years in terms of developing and improving the basic infrastructure, as evidenced by the completed or ongoing projects mentioned. It is very important that the infrastructure modernization process be continued, in order to eliminate the existing gaps compared to the other member states of the European Union, the effects also affecting the local socio-economic development.

The distribution of electricity in the Liteni town is provided by E-ON Moldova and according to the preliminary data received from the City Hall of Liteni, a share of 94.9% of the conventional homes registered in the Liteni town had an electrical installation at the last census.

However, **the supply of thermal energy** presents the most drastic change, due to the fact that at town level there is no centralized distribution of thermal energy, it causes the inhabitants to resort to their own methods of heating, which, for the inhabitants of the blocks, often represent a danger.

A future alternative for the production of thermal energy at low costs is the implementation of unconventional solutions for their production from renewable resources. A first step towards encouraging this solution is the presence of law number 220/2008 which establishes the system for the promotion of energy production from renewable energy sources.

An example in order to increase energy efficiency is the kindergarten with an extended program in Liteni, which underwent an extensive modernization process in this regard. Thus, photovoltaic panels with an installed power of 20 kW were mounted on its roof, serving the main consumers. For the preparation of domestic hot water, a thermal system consisting of 6 flat solar collectors was installed, which ensures the hot water needed for most of the year.

Kindergarten with extended program in Liteni town

Another investment was completed at the Kindergarten with normal program in Liteni. The thermal rehabilitation of the building as well as the modernization of the premises were carried out through a project financed with government funds through the National Local Development Program, to which are added the funds allocated from the local budget.

Kindergarten with normal program in Liteni town

II. STUDIES CARRIED OUT WITHIN THE NESICA PROJECT

1. Carrying out the energy audit for the House of Culture-City Library

Based on the association agreement with the Stefan cel Mare University of Suceava, within the **"New Energy Solutions in Carpathian Area" - NESiCA** project, the energy audit was carried out for an important building in the Liteni town, namely the HOUSE OF CULTURE-URBAN LIBRARY in order to rehabilitate and its modernization.


The House of Culture-City Library of the Liteni town, Suceava county

The implementation of the intervention works proposed by the energy audit has the effect of reducing maintenance costs for utilities, reducing the effects of climate change, by reducing greenhouse gas emissions as a result of reducing fuel consumption and improving the architectural appearance of the Liteni town, Suceava county.

The building is oriented with the main facade (entrance) to the South-West. The construction has a height regime of partial semi-basement plus ground floor. The spaces related to the building currently have the following destinations:

Ground floor	[m^2]
Library	66,95
Small hall	66,95
Kitchen	23.40
Scene	42.25
The big hall	168,72
Hall	42,52
Shed	14.10
Sanitary group	8,89
Total	**437,57**

The resistance structure of the building is made up as follows:
- the structure of the building in load-bearing brick masonry with concrete foundations;
- wooden floor over the ground floor covered with planks and reeds;
- the roof is made of wooden frame and galvanized sheet covering.

The exterior carpentry is replaced (almost entirely) with PVC carpentry and double glazing. The free height of the rooms is 4.00 m and 3.85 m, respectively. The building is connected to the following utilities:

- electricity supply;
- road and pedestrian access.

Currently, the building does not have a domestic hot water installation. Terracotta stoves for local heating are used for heating. On the facade of the building there are 8 SPLIT type air conditioning equipment (HYUNDAI INVERTER 12000 BTU/h) for the air conditioning of the performance hall and the library.

The House of Culture-City Library of the Liteni town. Inverter heating system

The energy rating of the building is made according to the specific consumption corresponding to the utilities in the building and the penalties established according to the operation. The classification in energy classes is done according to the specific energy consumption for each type of consumer according to the specific energy scale.

The total annual specific energy consumption can be seen in the table below, where q_h represents the specific annual energy consumption for heating [kWh/m^{2}year], q_{acc} represents the specific annual energy consumption for the preparation of domestic hot water [kWh/m^{2}year], w_{ilum} represents the specific annual energy consumption for lighting [kWh/m^{2}year] and q_{clim} represents the specific annual energy consumption for air conditioning.

q_h [kWh/m^2 year]	q_{acc} [kWh/m^2 year]	q_{clim} [kWh/m^2 year]	w_{ilum} [kWh/m^2 year]	q_{tot} [kWh/m^2 year]
530,96	42,84	21,67	19,53	**615,00**

The evaluation of the energy performance of the building was determined by:

- Calculation of tire elements;
- Energy consumption for heating;
- Energy consumption for domestic hot water;
- Energy consumption for air conditioning;
- Energy consumption for lighting;
- Calculation of primary energy consumed and CO_2 emissions.

Following the calculations, a series of energy modernization measures were identified, after which a technical and economic analysis of the proposed modernization measures was carried out.

The House of Culture-City Library of the Liteni town. Stove heating system

The House of Culture-City Library of the Liteni town. Roof structure

The House of Culture-City Library of the Liteni town. Bridge insulation

Following the calculations, a series of energy modernization measures were identified, after which a technical and economic analysis of the proposed modernization measures was carried out.

IDENTIFICATION OF MODERNIZATION MEASURES. REHABILITATED BUILDING

Solution package 1

- thermal insulation of the external walls with 10 cm of fireproof expanded polystyrene and on the contour of the carpentry gaps with 3 cm of fireproof extruded polystyrene;
- thermal insulation of the plinth on the outer face with 8 cm fireproof extruded polystyrene;
- thermal insulation of the floor towards the bridge with 20 cm of basalt wool.
- replacement of the exterior carpentry with energetically efficient carpentry equipped with ventilation grills.

Solution package 2

- thermal insulation of the external walls with 10 cm of fireproof expanded polystyrene and on the contour of the carpentry gaps with 3 cm of fireproof extruded polystyrene;
- thermal insulation of the plinth on the outer face with 8 cm fireproof extruded polystyrene;
- thermal insulation of the floor towards the bridge with 20 cm basalt mineral wool;
- replacing the external carpentry with energetically efficient carpentry equipped with ventilation grills;
- equipping the building with a heating installation with its own thermal plant and static heaters;
- equipping the building with a hot water installation;
- replacing the incandescent lamps in the electrical lighting installation with fluorescent lamps with low electricity consumption and rehabilitating the lighting installation.

Solution package 3

- thermal insulation of the external walls with 10 cm of fireproof expanded polystyrene and on the contour of the carpentry gaps with 3 cm of fireproof extruded polystyrene;
- thermal insulation of the plinth on the outer face with 8 cm fireproof extruded polystyrene;
- thermal insulation of the floor towards the bridge with 20 cm basalt mineral wool;
- replacing the external carpentry with energetically efficient carpentry equipped with ventilation grills;
- equipping the building with a heating installation with its own thermal plant and static heaters;
- equipping the building with a hot water installation;
- installation of alternative thermal and electrical energy production systems;
- installation of a mechanical ventilation system with heat recovery to ensure indoor air quality and comfort conditions in occupied spaces;
- replacing the incandescent lamps in the electrical lighting installation with fluorescent lamps with low electricity consumption and rehabilitating the lighting installation.

As part of the audit, the effect of the installation of thermal and electrical energy production systems on greenhouse gas emissions was also analyzed.

The effect of installing alternative thermal and electrical energy production systems on greenhouse gas emissions:

a) Alternative thermal energy production systems (heat pump):

- the estimated annual requirement of thermal energy for heating and the preparation of hot water for consumption after rehabilitation: 50587.95 kWh/year;
- the average performance coefficient of the heat pump: COP=3;
- the minimum amount of thermal energy estimated to be produced annually with the help of the heat pump (30 % of the estimated annual thermal energy requirement): 15176.38 kWh/year;
- the minimum amount of cold for cooling estimated to be produced annually with the help of the heat pump (50 % of the estimated annual energy requirement for air conditioning): 3256.61 kWh/year;
- annual energy saving as a result of using the heat pump: 12288.66 kWh/year;

b) Alternative electricity production systems (photovoltaic panels):

- estimated annual electricity requirement after rehabilitation (lighting and heat pump operation): 12864.75 kWh/year;
- the minimum amount of electricity estimated to be produced annually from local RES (10% of the estimated annual electricity demand): 1286.48 kWh/year;
- annual electricity savings: 1286.48 kWh/year.

Cumulative effects:

- the estimated annual energy requirement of the building after rehabilitation: **63821.59 kWh/year**;
- total consumption covered by renewable energy sources: **21.27% (13575.14 kWh/year)**;
- the annual reduction of CO_2-equivalent greenhouse gas emissions as a result of the use of local renewable energy sources: **1463.02 [kgCO_2/year]**;
- total annual energy savings (compared to the non-rehabilitating building situation): **218861.25 kWh/year**;
- the total annual reduction of CO_2-equivalent greenhouse gas emissions: **6705.71 [kgCO_2/year]**.

The installation of a mechanical ventilation system does not result in energy savings compared to the existing situation, but it is required to ensure indoor air quality and comfort conditions in the occupied spaces.

ECONOMIC ANALYSIS OF BUILDING ENERGY MODERNIZATION SOLUTIONS

During the energy audit, the options for improving the thermal performance of the tire and the installations presented above were analyzed.

Input data:

a) utility costs:

- thermal energy: 0.060 euro/kWh;
- electricity: 0.130 euro/kWh;

b) heat-insulating materials and installation equipment (estimated prices, without VAT - offers from construction and execution material companies):

- expanded polystyrene: 40 euros/m^2;
- extruded polystyrene: 95 euros/m^2;
- basalt wool: 90 euros/m^2;
- materials + workmanship without polystyrene exterior walls 30 euros/m^2;
- materials + labor without basalt wool thermal insulation upper floor 25 euros/m^2;
- materials + labor without polystyrene lower floor 4 euros/m^2.

The annual saving of thermal energy and electricity, respectively, as a result of the insulation of the building envelope and the modernization of the heating, domestic hot water and lighting installations:

Solution package 1

$$\Delta E_t = 157873{,}74[\text{кВт-год/рік}]$$

Solution package 2

$$\Delta E_t = 203459{,}11[\text{кВт-год/рік}]$$
$$\Delta E_e = 1827{,}00[\text{кВт-год/рік}]$$

Solution package 3

$$\Delta E_t = 215747{,}78[\text{кВт-год/рік}]$$
$$\Delta E_e = 3113{,}48[\text{кВт-год/рік}]$$

CONCLUSIONS

The implementation of the intervention works proposed by this energy audit has the effect of reducing maintenance costs for utilities, reducing the effects of climate change, by reducing greenhouse gas emissions as a result of reducing fuel consumption and improving the architectural appearance of the Liteni town, Suceava county.

Solution Package 3 from the energy audit is recommended, which allows compliance with the minimum energy performance requirements provided for in technical regulation Mc 001/1-2006 (supplemented by Order 2641/2017).

Next, the most important data resulting from the energy audit are centralized:
- annual specific energy consumption for heating for the audited building: 530.96 kWh/m^2 year;
- the total annual specific consumption of primary energy for the audited building: 727.65 kWh/m^2 year;
- the specific annual index of CO_2 equivalent emissions: 23.22 kgCO_2/m^2 year;
- the energy performance of the audited building (energy rating): 66.05;
- global thermal insulation coefficient G1 for the audited building: 0.82 W/m3K;
- global thermal insulation coefficient G1ref. of the reference building: 0.37 W/m^3K;

Solution package 3:
- investment recovery period, under conditions of economic efficiency: 8.39 years;
- global thermal insulation coefficient G1 for the rehabilitated building: 0.28 W/m^3K;
- specific annual energy consumption for heating corresponding to the rehabilitated building: 85.27 kWh/m^2 year;
- annual energy saving: 218861.25 kWh/year; 18.82 t.e.p.; 81.33%;
- the specific annual primary energy consumption of the building from non-renewable sources for heating the building: 92.09 kWh/m^2 year;
- the specific annual index of CO_2 equivalent emissions: 7.90 kgCO_2/m^2 year;
- the estimated annual decrease in CO_2-equivalent greenhouse gas emissions: 6.70 tons CO_2/year (6705.71 kgCO_2/year);
- the specific investment, without VAT (construction - installations/useful area): 1,254 thousand lei/m^2a.u.

Since the existing building does not meet the current requirements regarding the energy performance of buildings, it is recommended to rehabilitate the building thermally and fit the building into the minimum energy performance requirements provided in the technical regulation Mc 001/1-2006 (supplemented by Order 2641/2017):

- global thermal insulation coefficient G ≤ G1ref [W/m^3K];
- the specific annual consumption of primary energy from renewable sources for heating the building: $q_{year} \leq q_{year,max}$ *($q_{year,max}$ = 123 [kWh/m^2 year], building for culture).*

2. ENERGY PERFORMANCE CERTIFICATE FOR THE HOUSE OF CULTURE-CITY LIBRARY OF THE LITENI TOWN

The energy performance certificate for the House of Culture-City Library of Liteni town, Suceava county, was made based on the calculation methodology of the Energy Performance of Buildings developed in application of Law 372/2005. The energy certification of the building is made according to the total energy consumption of the building, estimated by the thermal and energy analysis of the construction and related installations. The energy rating of the building takes into account the penalties due to the irrational use of energy.

Characteristics of the certified building:

- Useful area: 437.57 m^2;
- Building category: House of Culture and City Library;
- Built-up area: 540.57 m^2;
- Height regime: Dp+P;
- Internal volume of the building: 1685.36 m^3;
- Year of construction: 1924-1930.

The following data were taken into account:

1. Annual specific energy consumption: 615 kWh/m^2 year (Certified Building) / 158.71 kWh/m^2 year (Reference Building);

2. CO_2 equivalent emission index [kgCO_2/m^2 year]: 23.22 kWh/m^2 year (Certified Building) / 12.13 kWh/m2 year (Reference Building).

Annual specific energy consumption [kWh/m^2year] for:		Energy class	
		Certified building/Reference building	
Heating	530,96	G	B
Domestic hot water	42,84	C	B
Conditioning	21,67	B	A
Mechanical ventilation	–	–	–
Artificial lighting	19,53	A	A

The energy performance of the reference building can be identified in the following table.

Annual specific energy consumption [kWh/m^2year] for:		Energy rating
Heating: Domestic hot water: Air conditioning: Mechanical ventilation: Lighting:	530,96 42,84 21,67 – 19,53	**66,05**

The House of Culture-City Library of the Liteni town, Suceava county

The specific annual consumption of energy from renewable sources is considered equal to 0, the building not having implemented sources of thermal and electrical energy production. In the following, the data obtained regarding the assessment of the energy performance of the building, respectively the energy classification grids of the building according to the specific annual heat consumption, are presented.

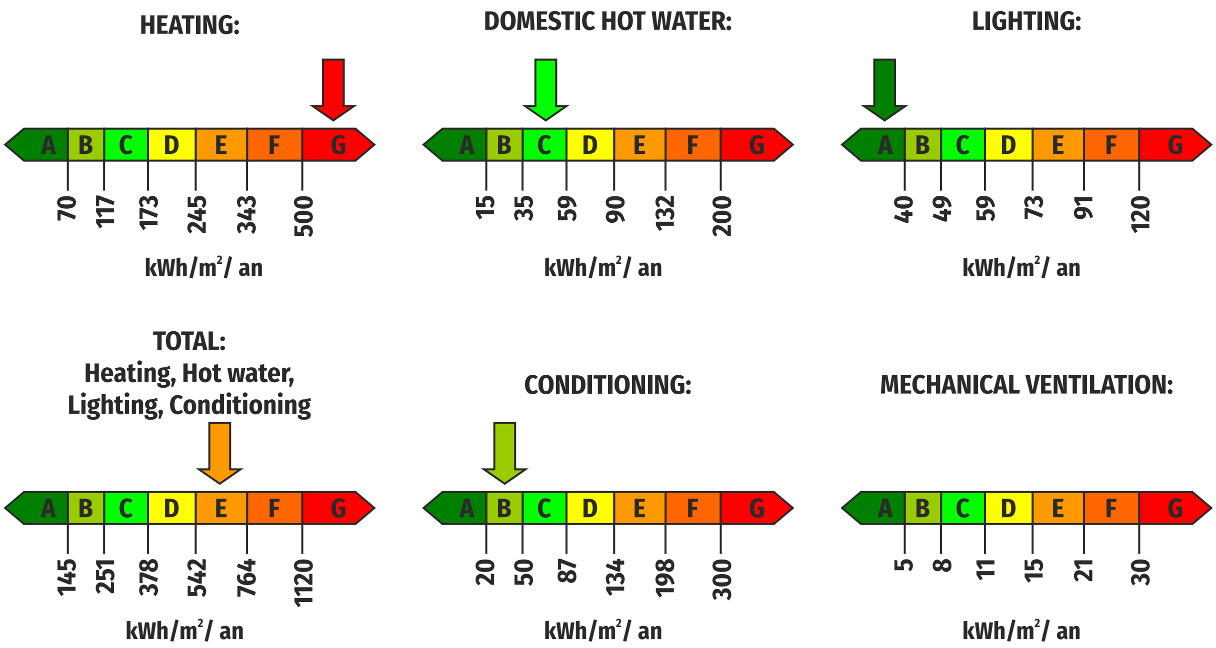
Recommendations for reducing costs by improving the energy performance of the building:

A. Recommended solutions for the building envelope

- Thermal insulation of external walls;
- Thermal insulation of the upper floor;
- Thermal insulation of the lower floor;
- Replacement of exterior carpentry with energetically efficient carpentry.

B. Recommended solutions for the installations related to the building

- Equipping the building with a modern heating system and domestic hot water installation;
- Use of renewable energy sources to provide utilities in the building;
- Introduction of an organized mechanical ventilation system.

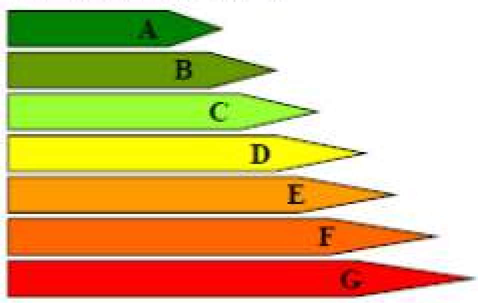


Energy classification grids of the building depending on the specific annual heat consumption

Cod poștal localitate	Nr. înregistrare la Consiliul Local	Data înregistrării
7 2 7 3 3 5		z z l l a a

Certificat de performanță energetică

Performanța energetică a clădirii	Notare energetică	**66,05**
Sistemul de certificare: *Metodologia de calcul a Performanței Energetice a Clădirilor elaborată în aplicarea Legii 372/2005*	Clădirea certificată	Clădirea de referință
Eficiență energetică ridicată ... Eficiență energetică scăzută	E	B
Consum anual specific de energie [kWh/m²an]	615,00	158,71
Indice de emisii echivalent CO_2 [kg_{CO2}/m²an]	23,22	12,13



Consum anual specific de energie [kWh/m²an] pentru:		Clasă energetică	
		Clădirea certificată	Clădirea de referință
Încălzire	530,96	G	B
Apă caldă de consum	42,84	C	B
Climatizare	21,67	B	A
Ventilare mecanică	-	-	-
Iluminat artificial	19,53	A	A

Consum anual specific de energie din surse regenerabile [kWh/m²an]: 0

Date privind clădirea certificată:
Adresa clădirii: oraș Liteni, str. Primăriei, jud. Suceava
Categoria clădirii: Casa de cultură și Biblioteca orășenească — Aria utilă: 437,57 m²
Regim de înălțime: Dp+P — Aria construită desfășurată: 540,57 m²
Anul construirii: 1924-1930 — Volumul interior al clădirii: 1685,36 m³
Scopul elaborării certificatului energetic: **reabilitare și modernizare**

Programul de calcul utilizat: calcul Excel – program propriu **versiunea:** 2019

Date privind identificarea auditorului energetic pentru clădiri:

Specialitatea (c, i, ci)	Numele și prenumele	Seria și nr. certificat de atestare	Nr. și data înregistrării certificatului în registrul auditorului	Semnătura și ștampila auditorului
I c, i	**Atănăsoae Pavel**	**B_A 00776, B_A 00844**	**1260/21.09.2020**	

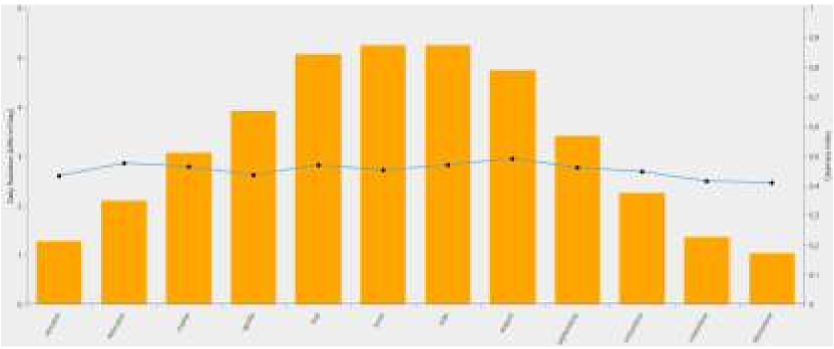
Certificarea energetică a clădirii este făcută funcție de consumul total de energie al clădirii, estimat prin analiza termică și energetică a construcției și instalațiilor aferente.
Notarea energetică a clădirii ține seama de penalizările datorate utilizării neraționale a energiei.
Perioada de valabilitate a prezentului Certificat Energetic este de 10 ani de la data eliberării acestuia.

Виготовлено сертифікат енергоефективності для будинку культури/міської бібліотеки міста Літені

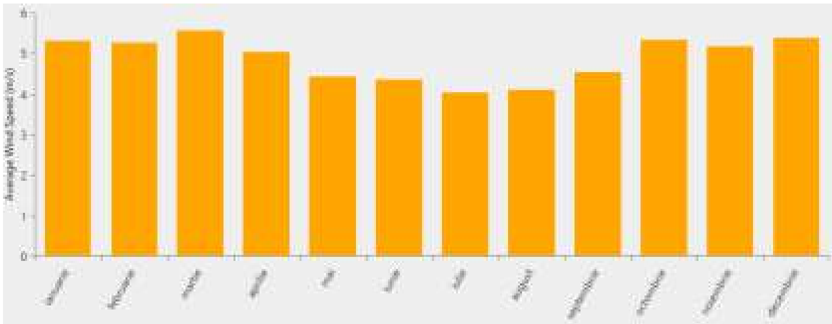
III. SOLUTIONS PROPOSED WITHIN THE NESICA PROJECT REGARDING INCREASING ENERGY EFFICIENCY

Implementation of a hybrid electricity production system for the House of Culture-City Library building, Liteni town, Suceava county

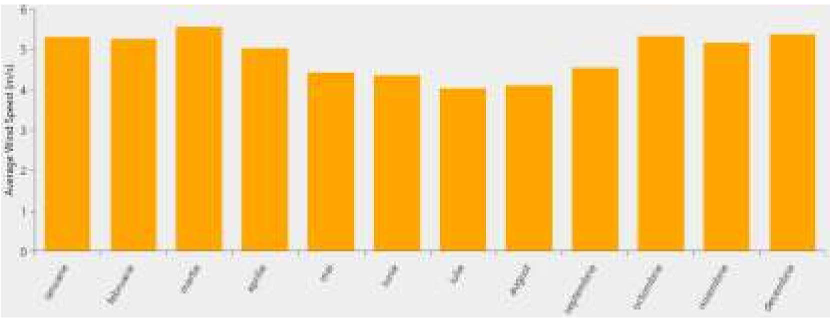
The region of Liteni town is characterized by moderate values of solar irradiance, temperature and wind speed, slightly higher than other regions from North-East of Romania, as can be seen from the following representations. The average value of the solar irradiance is 3.23 kWh/m^2/day, and that of the wind speed is 4.88 m/s, while the average daily temperature value in the Liteni town region is 7.94 °C.



Average monthly value of solar irradiance in the region of Liteni town



Daily average values of wind speed in the region of Liteni



Average daily temperature values in the region of Liteni

In this chapter, a series of solutions are proposed for the supply of electricity from renewable sources for the House of Culture-City Library building in order to increase energy efficiency. It should be stated that the implementation of renewable energy sources is possible for all buildings managed by the local community. The simplest measure to implement refers to photovoltaic sources that can be integrated into the structure of buildings or mounted and exploited using a neighboring land area. The disadvantage of the implementation of these photovoltaic sources boils down to the climatic conditions in the North-East area, which are not comparable, for example, to those in the South of Romania. It is also recommended to use photovoltaic panels as a source of electricity production in parallel with heat pumps for heating buildings.

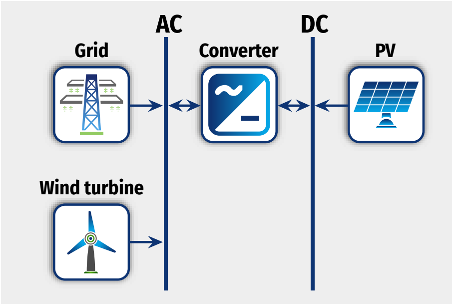
In the following, some environmental aspects are presented regarding the implementation of photovoltaic sources on the House of Culture-City Library building.

The study follows the recommendations of the experts who prepared the energy audit. Thus, the photovoltaic system will be dimensioned in such a way as to cover the annual electricity requirement of the building.

According to existing data, the electricity consumption of the House of Culture-City Library building is 12.9 MWh/year, consumption valid for the rehabilitated building following the application of solution plate no. 3. The electricity consumption mentioned is to cover the consumption of the lighting system and that of the heat pump. To compensate for this amount of electricity, it is recommended to install photovoltaic panels on the roof of the building with a total installed power of 12 kW. The use of a wind turbine represents a secondary source of electricity production given the rather low monthly average values of the wind speed.

Liteni town, Suceava county. Geographical location

The purpose of the study is identified in the analysis of the operation of a hybrid system of electricity production consisting of photovoltaic panels in parallel with a small power wind turbine. The operation block diagram of the on-grid photovoltaic system includes a photovoltaic source with an installed power of 12 kW, a wind turbine with a nominal power of 1 kW and an inverter for transferring the energy produced to the network, according to the operation block diagram.



Functional block diagram of the hybrid power generation system.

For the analysis of the operation of the on-grid photovoltaic system, the following were established:

1. Photovoltaic panels are mounted on the roof of the building, which excludes the use of an orientation system. The tilt angle for the panels was set to 47°.

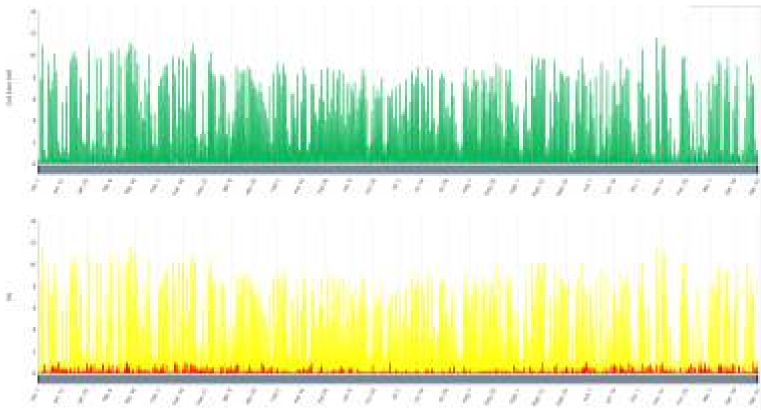
2. The following were taken into account: the effect of temperature (-0.50%/°C) on the power produced by the photovoltaic panels, the efficiency of the panels given by the manufacturer under standard test conditions (21%) and the standard operating temperature of the photovoltaic cell (47°C).

The results obtained from the modeling highlight a series of characteristics of the proposed system, centralized in the following table. It is found that the proposed system will produce, in the specific climatic conditions of the analysis area, a quantity of electricity in the amount of 14.147 MWh/year.

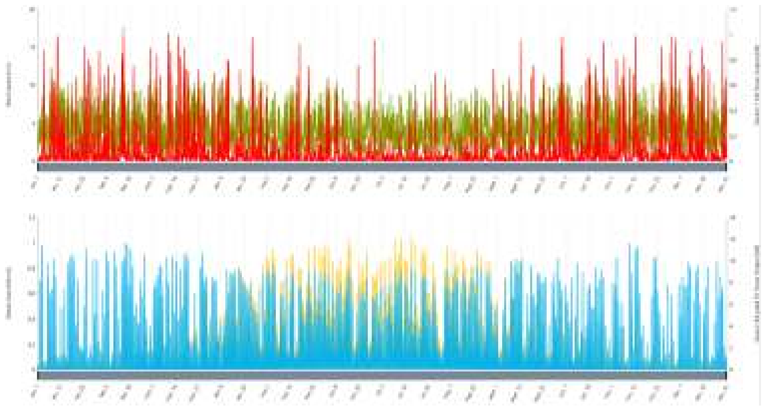
Characteristics of the photovoltaic system		
The amount of energy produced per year	**13495**	**kW/h**
The average amount of energy produced per day	37	kW/h
Maximum power produced	11.6	kW
Capacity factor	12.8	%
Hours of work	4375	Hour/year
Characteristics of wind turbines		
The amount of energy produced per year	**652**	**kW/h**
Capacity factor	7,44	%
Hours of work	5984	Hour/year
Maximum power produced	1	kW
Average produced power	0,0744	kW

Electric energy is fed into the power grid		
January	924	kW/h
February	1067	kW/h
March	1308	kW/h
April	1198	kW/h
May	1345	kW/h
June	1255	kW/h
July	1296	kW/h
August	1309	kW/h
September	1158	kW/h
October	1017	kW/h
November	812	kW/h
December	783	kW/h
TOGETHER	**13472**	**kW/h**

The following figure illustrates the variation of the power injected into the electrical network as an effect of the power produced by the two renewable sources (photovoltaic and wind). Afterwards, the power generated by the wind turbine and the photovoltaic system is represented in relation to the wind speed and the distribution of the global component of solar irradiance.



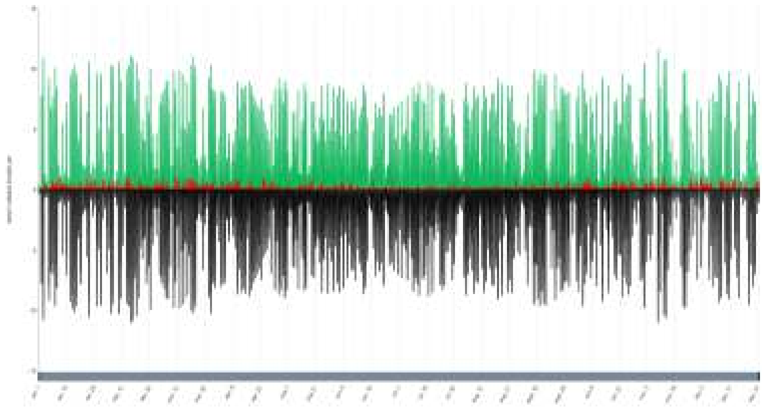
The electric power injected into the network and the power produced by each source, in a year



The power produced by the wind turbine and the photovoltaic system in relation to the wind speed and solar irradiance

It is found that the wind turbine will operate at 95% of the nominal power only at a few moments in a year. Otherwise, the average power produced is limited to around 100 W.

The following representation highlights the power produced by the wind turbine compared to the power produced by the photovoltaic system as well as the difference between the two powers considered.



The power produced by the wind turbine in relation to the total power injected into the grid.

CONCLUSIONS

By implementing a hybrid electricity production system with a total installed power of 13 kW, the building can cover its electricity consumption of 12.9 MWh/year. The installation of a wind turbine (included in the analysis) is optional as it brings a maximum power input of 4.6% of the total 14147 kWh/year due to unfavorable wind conditions. The increase in the power produced by the wind turbine can be made possible by increasing the height of the tower, from 17 m to 34 m. This means 892 kWh/year compared to 652 kWh/year, so an increase of only 1.6% which in terms of financially it is not profitable.

IV. RESOURCES FOR THE IMPLEMENTATION OF THE BEST ENERGY EFFICIENCY SOLUTIONS IN THE LITENI TOWN

The local development strategy of the Liteni town was developed in the context of a new programming of European funds for the period 2021-2027, which generated the revitalization of strategic approaches, both at the European level and at the national level. Thus, in the process of developing this strategy, emphasis was placed on reporting to all similar strategic documents (in progress or recently completed).

One of the reference documents of the Ministry of Foreign Affairs is Agenda 2030, which aims to create favorable conditions for economic growth through Global Objectives such as: the development of cities and human settlements so that they are open to all, safe and sustainable, strengthening the means of implementation and revitalizing the global partnership for sustainable development, promoting sustained, inclusive and sustainable economic growth, full and productive employment, etc. In this sense, 17 essential objectives were established, covering areas such as health, education, environment, economy, etc.

The strategy of the Liteni town is based on these objectives, through the established measures, which aim at the development of local businesses, the stimulation of innovation and the economy based on know-how, the development of an economy that attracts investors, the specialization of human capital, the protection of the environment and the promotion of the efficient use of natural resources.

Another national strategic document to which the Liteni Town Local Development Strategy refers is the Sustainable Development Strategy of Romania 2013-2020-2030. It establishes concrete objectives regarding the transition to a sustainable development, based on improving the quality of people's lives and the relationships between them in harmony with the natural environment. Under this aspect, the strategy of the Liteni town takes into account the enhancement of the natural environment and the capitalization of the natural resources it possesses.

Within this document, a set of five types of funds was proposed, respectively for: the European Regional Development Fund (ERDF), the European Social Fund Plus (FSEP), the Just Transition Fund (FTJ) and the Cohesion Fund (FC). According to the 2021-2027 legislative package proposed by the European Commission, the allocations dedicated to Romania from the Cohesion Policy funds amount to approximately 31 billion euros (current prices) and are distributed as follows: European Regional Development Fund – 17.715 billion euros, including 392 million euros for Cooperation European Territorial, of which:

- 30% of the total ERDF allocation is for interventions that will contribute to the fulfillment of climate objectives;
- 37% of the total FC allocation is for interventions that will contribute to meeting the climate objectives;
- 6% of the total ERDF allocation is for interventions that will contribute to sustainable urban development.

The economic development strategy of the Liteni town for the period 2021 – 2027 includes the project for the **thermal rehabilitation of residential buildings** worth 3,000,000 million euros. The purpose of the project is to improve the urban infrastructure and increase the energy efficiency through the thermal rehabilitation of the blocks of flats in the Liteni town. One of the performance indicators considers the number of thermally rehabilitated blocks. The specific objectives of the project are:

- improving the thermal insulation of the blocks of flats in the Liteni town in order to increase the
- quality of life of the inhabitants;
- improving the appearance of apartment blocks in the Liteni town.

The main activities refer to:

- identification and inventory of blocks that require thermal rehabilitation interventions;
- design of intervention works;
- execution of intervention works;
- reception upon completion of the works and issuance of the energy performance certificate.

The sources of funding available for the completion of the project, with an implementation period of 2021-2024, are from the local budget, government funds and non-reimbursable European funds.

5.2 VAMA COMMUNE

I. General presentation. Current situation and challenges.

Vama commune is located in Suceava county, belonging to the North-East Development Region. Suceava County is part of the North-East Development Region together with 5 other counties: Iași, Vaslui, Botoșani, Bacău and Neamț. Suceava county is located in the region of Moldova, the north-eastern part of Romania and borders Ukraine to the north, Botoșani county to the east, Iași county to the south-east, Neamț, Harghita and Mureș counties to the south, and to the west with Bistrita Năsăud and Maramureș counties.

Vama commune is located in the western part of Suceava county, at the confluence of the Moldova and Moldovita rivers, at a distance of 14 km from the municipality of Câmpulung Moldovenesc and 53 km from the municipality of Suceava, the county seat. The locality has altitudes between 600 and 800 m. As neighbors, the Vama commune is limited to the northwest by the Frumosu commune, to the northeast by the Mănăstirea Humorului commune, to the southeast by the town of Frasin, to the south by the Stulpicani commune and to the south-west with the municipality of Câmpulung Moldovenesc.

The administrative territory of the Vama commune has a total area of 13628 ha, and the commune is composed of 4 villages, and they are: Molid, Prisaca Dornei, Strâmtura and Vama. It is located between the two rivers Moldova and Moldovița, "guarding" the entrance to the Eastern Carpathians, respectively to Transylvania. The name "customs" comes from the geographical location and the duties that the "greats of the time" had in this locality, i.e. at the customs, respectively the tax collector
(http://www.comuna-vama.info/primarie/).

Communities names		Total population	Total area (km²)	Density population (km²)
Commune	Villages and hamlets			
Vama	Molid, Prisaca Dornei, Strâmtura and Vama	5307	136,28	39

Vama Commune represents 10.02% of the total area of the Bucovina de Munte micro-region, with an area of 1.359,17 km^2.

Geographic coordinates: northern latitude 47° 33' 38.3472'' N; east longitude 25°41' 16.8468'' E.

The relief. The territory of Suceava County is characterized by a wide variety of landforms explained by its vast size. Compared to the large geographical units of the country, the territory of the county partially overlaps the Eastern Carpathians and the Suceava Plateau. From west to east, the relief registers a gradual decrease in altitude, the types of forms being oriented in strips with a north-south direction and generally parallel to each other. The predominant landforms are mountains, hills and plateaus. The mountainous areas occupy 2/3 of the county's territory and are characterized by extensive forests and natural meadows, rich spa and tourist resources. The mountain region includes the Eastern Carpathians represented by the Bârgău Mountains, partially the Călimani Mountains, scapes (Mestecăniș, Feredău), the Bistriţei Mountains (Rarău Mountain, Giumalău Mountain, Bârnaru Mountain, Budacu Mountain) and Stânișoara Mountains (only Sutra Mountain).

The commune of Vama is predominantly located in the mountain area, at the confluence of the Moldova and Moldovița rivers, a mountain depression formed along the Moldova river by the peaks of the Mestecăniș Municipality. Forests occupy 70% of the commune's surface, a percentage that ranks it among the regions with the largest forest areas in the country. The relief is predominantly depressional, the commune of Vama being located between the Feredeului slope, the Humorului slope and the Rarău Massif. The average annual temperature is 3-7 degrees Celsius and the average annual rainfall is 600-1000 l/m^2. Fog is common in the cold season.

Climate. The geographical space of Suceava county belongs almost equally to the sector with a continental climate (the eastern part) and with a continental-moderate climate (the western part). As a result of the varied relief that includes hills, plateaus, depressions, mountain peaks and the climate oscillates between the mountainous climate with a more pronounced continental character to the more "gentle" hill and plateau climate. Considering the positioning of the commune of Vama in the Obcinele Bucovina, we can say that it enjoys a climate specific to the low and middle mountainous regions, devoid of the prolonged low temperatures, winds and humidity of the high peaks, as well as the excessive heat of theextra-Carpathian regions.

The climatic factors that characterize the commune of Vama are the following:

Temperature. The average temperatures of the hottest months, July – August, are around 15°C, and of the cold months, December – February, around 5°C. The average annual temperature varies between 6 and 8 degrees Celsius; the continental climate results in long, cold winters and short, cool springs.

The winds. The direction of the winds is coincident with the direction of the towns and the main valleys, which explains the predominance of the winds from the N-W, which can locally change depending on the configuration of the relief; winds in the eastern sector have a reduced frequency and duration.

The precipitation. Average annual precipitation, in the micro-region of which it is a part, varies between 600 l/m^2 in the eastern area and 700 l/m^2 in the north-west area. The lowest amounts of precipitation are recorded in February, and the richest in the interval of May-July, when about 45%

of the annual amount of precipitation occurs. Snow is present from November to April and averages between 30 - 50 cm. The hydrographic network of the entire county totals 3092 km and belongs entirely to the Siret hydrographic basin due to the general configuration of the relief. The density of hydrographic networks is 0.361 river km/km2, a value higher than the average for the country. The rivers on the territory of Suceava county are: Siret, Suceava, Moldova, Bistrița, Somuzu Mare and Dorna. Of these, the Dorna river is a tributary of the Bistrita river, the rest being tributaries of the Siret river. The Siret River has 26.47% of its total length on the territory of Suceava County. The rivers that cross Vama commune are: Moldova and its afluents: Hurghiș, Moldovița, Doabra. The hydrographic network on the territory of the commune of Vama faithfully follows the configuration of the hydrographic network in the Obcinile Bucovina, in the sense that the rectangular network type predominates. The territory of the commune stands out for its wealth of underground and surface water, a fact determined by the geological composition, climate and relief.

Current state of the energy system. The energy equipment represents the length of the electricity supply network of the municipality together with the number of households connected to the electricity network as well as the degree of equipment of the homes. The commune of Vama is supplied with electricity from the overhead medium voltage distribution network (LEA 20 kV). Regarding the energy equipment of the Vama commune, in 2018 there were 3113 households connected to the electricity network, with a length of the energy network of 65 km. The degree of equipping homes with electricity is 98%. In the commune of Vama there are 32 km of lighted streets with an expansion degree of the public lighting network of 88%. Currently there are projects for the expansion, modernization and efficiency of the public lighting network, through which LED lighting fixtures will be installed.

For year 2019, a series of energy consumption indicators were established in the public buildings sector.

There are 12 public buildings in the Vama commune: 1 dispensary, 7 schools and kindergartens for university education, 2 cultural hostels, 1 stadium and the Vama town hall. In total, the total useful heated area is 5261 m^2. Thus, in 2019 the consumption of electricity was 143 MWh/year and the consumption of thermal energy, with an efficiency of 85%, was 1411 MWh/year. The highest consumption of electricity and thermal energy, at the level of 2019, was recorded for the 7 schools and kindergartens in pre-university education.

Current measures to increase energy efficiency in Vama commune

Monitoring and evaluation usually starts from the first steps of the project and continues after the completion of the implementation of the measures in order to establish the long-term impact of the program on the local economy, energy consumption, environment and human behavior.

In the following, the energy efficiency measures implemented in Vama commune for a series of public buildings are presented: Vama Human Dispensary, Vama Secondary School (high school), Iorgu G. TOMA Secondary School and Kindergarten Strâmtura, Kindergarten no. 1 Iorgu G. TOMA Vama de Sus, Grădinita no. 2 Vama, Kindergarten with normal program Prisaca Dornei, Kindergarten with normal program Molid, Vama Cultural Home, Vama City Hall.

* Cladding the walls with polystyrene in the thermosystem, P+E expansion, fitting out bathrooms, replacing wooden carpentry with PVC thermal panels, LED lighting, replacing the covering with Lindab sheet metal, insulating the attic floor.

** Cladding the walls with polystyrene in the thermosystem, setting up the sanitary units, modernizing the classrooms, replacing the flooring, replacing the wooden carpentry with PVC thermopanels, LED lighting, replacing the covering with Lindab sheet metal, insulating the bridge floor.

*** Cladding the walls with polystyrene in the thermo-system, fitting out the sanitary units, modernizing the classrooms, replacing the flooring, replacing the wooden carpentry with PVC thermal panels, LED lighting, replacing the cladding with Lindab sheet metal, insulating the bridge floor, installing the electrical power plant.

**** Cladding the walls with polystyrene in the thermos-system, setting up the sanitary units, modernizing the classrooms, replacing the flooring, replacing the wooden carpentry with PVC thermal panels, LED lighting, replacing the cladding with Lindab sheet metal, insulating the bridge floor, central heating installation.

****** Cladding the walls with polystyrene in the thermos-system, replacing the wooden carpentry with PVC thermal panels.

****** Cladding the walls with polystyrene in the thermos-system, expansion of the headquarters, placement of a solid fuel central heating system.

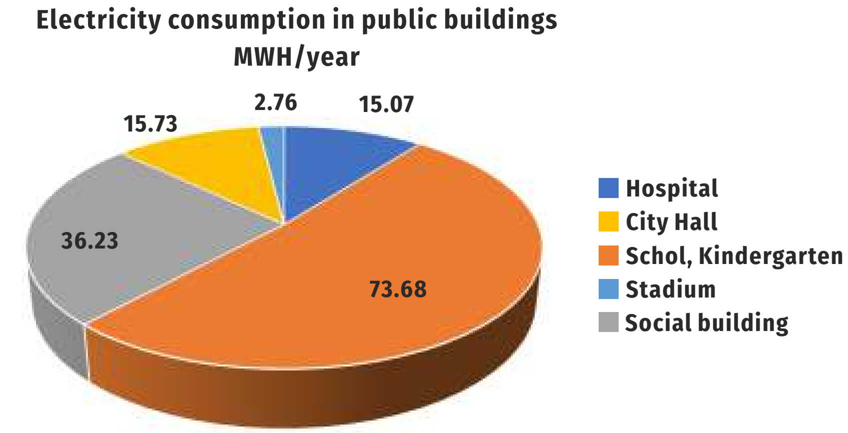
******* Replacing lighting fixtures with a high consumption of electricity with LED lighting fixtures equipped with a dimming system, which allow the adjustment of the light flow at the level of the entire investment objective in the Vama commune.

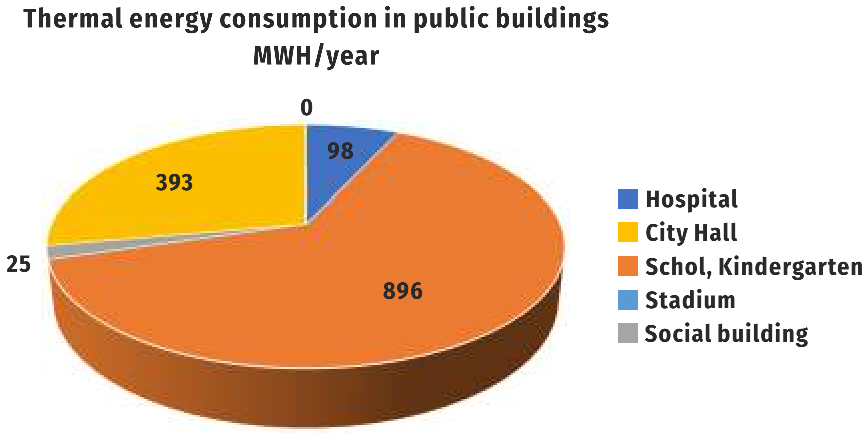
Nr. crt.	Consumption sector	Energy saving measures	Quantitative indicato	Year commissioning	Economy value (tep/year)	
					Estimated	Realised
1.	Vama Human Dispensary	Modernization of medical offices	-	2019	0,56	1.
2.	Secondary school (high school) Vama	*	Reduction of electricity consumption by 20%. Reduction of wood consumption by 25 mc/year	2020	64,4 1	64,4 1

3.	Iorgu G. TOMA secondary school and kindergarten Strâmtura	**	Reduction of electricity consumption by 20%. Reduction of wood consumption by 10 mc/year	2019	2,7 2	2,7 2
4.	Kindergarten no. 1 Iorgu G. TOMA Vama de Sus	***	Reduction of electricity consumption by 10%.	2019	0,06	0,06
5.	Kindergarten no. 2 Vama	****	Reduction of electricity consumption by 10%.	2012	0,0 8	0,0 8
6.	Kindergarten with normal program Prisaca Dornei	***	Reduction of electricity consumption by 10%.	2019	0,1 2	0,1 2
7.	Kindergarten with normal program Molid	***	Reduction of electricity consumption by 15%.	2019	0,0 9	0,0 9
8.	Vama cultural home	*****	Reduction of thermal energy consumption by 15%.	2012	0,4 3	0,4 3
9.	Vama City Hall	******	Reduction of thermal energy consumption by 15%.	2016	11. 92	11. 92

In perspective

1.	Road lighting Vama	*******	Reduction of electricity consumption by 20%.	2024	1,2	-





There are 4 kindergartens in Vama commune, with a total capacity of 120 places. The children carry out their didactic activities in 5 classrooms. Within the commune there are 3 institutions for primary and secondary education. They have a capacity of 625 places: 47.4% for primary education and 52.6% for classes in the cycle of secondary education. Within the commune there are 3 cultural hostels, where artistic performances are held. The activity is organized within the department of social assistance and libraries within the city hall.


Vama de Sus Kindergarten. Kindergarten Prisaca Dornei, Vama commune


Spruce Kindergarten, Vama commune


Secondary school no. 1 and no. 2, Vama commune


Strâmtura secondary school, Vama commune. "Iorgu G. Toma" Secondary School, Vama commune

II. STUDIES CARRIED OUT WITHIN THE NESICA PROJECT

Within the cross-border project New Energy Solutions in the Carpathian Area - NESICA, experts completed a series of studies for part of the buildings of the Vama commune. A first study refers to the preparation of the energy performance certificate for a thermally rehabilitated and modernized building, namely the Kindergarten with normal program in Molid, Vama commune.

I. Energy performance certificate for the kindergarten in Molid

The energy performance certificate for the kindergarten with normal program in Molid, Vama commune, was made based on the calculation methodology of the Energy Performance of Buildings developed in application of Law 372/2005. The development of the energy performance certificate was necessary in order to receive the modernization and thermal rehabilitation works carried out.

The energy certification of the building is made according to the total energy consumption of the building, estimated by the thermal and energy analysis of the construction and related installations. The energy rating of the building takes into account the penalties due to the irrational use of energy. The validity period of this Energy Certificate is 10 years from the date of its issuance.

Characteristics of the certified building:

- Usable area: 221.10 m^2 ;
- Building category: Educational building (Kindergarten);
- The developed built area: 261.40 m^2 ;
- Altitude regime: P;
- The interior volume of the building: 663.30 m^3;
- Year of construction: 1956 (modernization 2020).

The following data were taken into account:

1. Specific annual energy consumption: 127.10 kWh/m^2 year (Certified building) – 135.49 kWh/m^2 year (The reference building);

2. Equivalent emissions index CO_2 [kg CO_2 / m^2 year]: 29.11kWh/m^2 an (Certified building) / 31.03 kWh/m^2 year (The reference building).

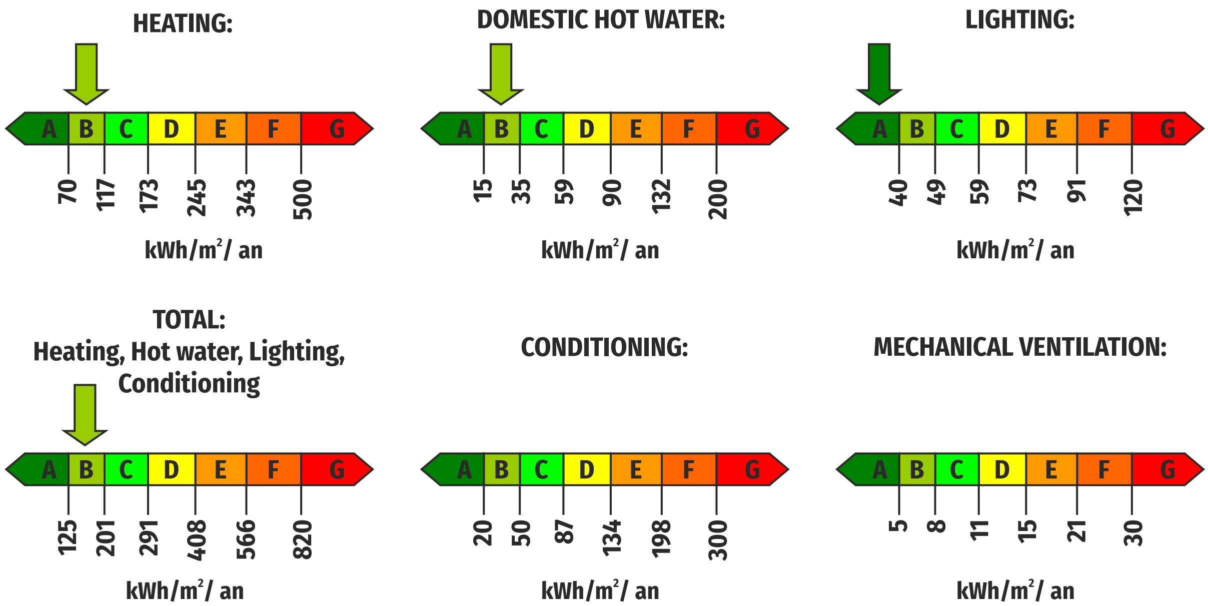
Annual specific energy consumption [kWh/m²year] for:		Energy class	
		Certified building/Reference building	
Heating	83,07	B	B
Domestic hot water	29,68	B	B
Conditioning	–	–	–
Mechanical ventilation	–	–	–
Artificial lighting	14,34	A	A

The energy performance of the reference building can be identified in the following table

Annual specific energy consumption [kWh/m²year] for:		Energy rating
Heating	91,46	98,9
Hot water	29,68	
Air conditioning	–	
Mechanical ventilation	–	
Lamplight	14,34	

Kindergarten with normal program Molid, Vama commune

The specific annual consumption of energy from renewable sources is considered equal to 0, the building not having implemented sources of thermal and electrical energy production. In the following, the data obtained regarding the assessment of the energy performance of the building, respectively the energy classification grids of the building according to the specific annual heat consumption, are presented.



Recommendations for reducing costs by improving the energy performance of the building:

A. Recommended solutions for the building envelope:

1. Ensuring indoor air quality through natural ventilation.

B. Recommended solutions for the installations related to the building:

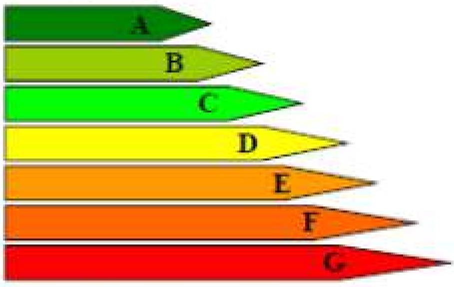
1. Adaptation of energy consumption to the reduced consumption requirement as a result of the rehabilitation works;

2. Regular recording of energy consumption;

3. Installation of renewable energy sources to ensure utilities in the building.

Cod poştal localitate	Nr. înregistrare la Consiliul Local	Data înregistrării
7 2 7 0 9 2		z z l l a a

Certificat de performanţă energetică

Performanţa energetică a clădirii	Notare energetică	**98,45**
Sistemul de certificare: *Metodologia de calcul a Performanţei Energetice a Clădirilor elaborată în aplicarea Legii 372/2005*	Clădirea certificată	Clădirea de referinţă
Eficienţă energetică ridicată  Eficienţă energetică scăzută	B	B
Consum anual specific de energie [kWh/m²an]	127,10	135,49
Indice de emisii echivalent CO_2 [kg_{CO2}/m²an]	29,11	31,03

Consum anual specific de energie [kWh/m²an] pentru:		Clasă energetică: Clădirea certificată	Clasă energetică: Clădirea de referinţă
Încălzire	83,07	B	B
Apă caldă de consum	29,68	B	B
Climatizare	-	-	-
Ventilare mecanică	-	-	-
Iluminat artificial	14,34	A	A

Consum anual specific de energie din surse regenerabile [kWh/m²an]: 0

Date privind clădirea certificată:
Adresa clădirii: sat Molid, com. Vama, jud. Suceava — Aria utilă: 221,10 m²
Categoria clădirii: Clădire de învăţământ (Grădiniţă) — Aria construită desfăşurată: 261,40 m²
Regim de înălţime: P — Volumul interior al clădirii: 663,30 m³
Anul construirii: 1956 (modernizare 2020)
Scopul elaborării certificatului energetic: **recepţie lucrări modernizare şi reabilitare termică**

Programul de calcul utilizat: calcul Excel – program propriu — **versiunea:** 2019

Date privind identificarea auditorului energetic pentru clădiri:

Specialitatea (c, i, ci)	Numele şi prenumele	Seria şi nr. certificat de atestare	Nr. şi data înregistrării certificatului în registrul auditorului	Semnătura şi ştampila auditorului
I c, i	**Atănăsoae Pavel**	**BA 00776, BA 00844**	**1265/14.10.2020**	

Certificarea energetică a clădirii este făcută funcţie de consumul total de energie al clădirii, estimat prin analiza termică şi energetică a construcţiei şi instalaţiilor aferente.
Notarea energetică a clădirii ţine seama de penalizările datorate utilizării neraţionale a energiei.
Perioada de valabilitate a prezentului Certificat Energetic este de 10 ani de la data eliberării acestuia.

The energy performance certificate made for the Molid kindergarten with a normal program

2. ENERGY EFFICIENCY IMPROVEMENT PROGRAM (EEIP) FOR UAT VAMA

The second study carried out for the commune of Vama refers to the drawing up of a program to improve energy efficiency. In order to carry out an energy management project, a series of information is required in relation to energy consumption accounts:

a) presentation of the main energy consumers by activity sector: residential, transport, utilities, services;

b) the general structure of consumption by types of energy - graphs, specifying the share of each form of energy consumed;

c) electricity: suppliers, distributors, description of the public lighting situation, cogeneration;

d) thermal energy: presentation of the situation of thermal energy supply at the local level;

e) natural gas;

f) liquid fuels: CLU, fuel oil, other used liquid fuels;

g) solid fuels: coal (lignite, coal, coke), combustible waste (sunflower husks, flax and hemp husks, sawdust, other agricultural waste), other used solid fuels;

h) fuels: diesel, gasoline, other used fuels;

i) water supply and sewage;

j) treatment stations;

k) data on the use of renewable energy (solar, wind, biomass, geothermal, hydro), estimates of the usable potential within the locality;

l) public buildings;

m) public transport;

n) urban waste.

It is also necessary to describe the evolution of energy consumption, based on the existing statistical data, with their interpretation, in relation to the events that occurred (weather, disconnections from the central heating system, increase in energy efficiency, etc.), during the last 3 years. Consumption evolutions will be presented: by activity sectors and by types of energy carriers.

For the realization of the energy efficiency improvement program (PIEE), the regulations in force at the time of the performance of the contracted works were taken into account, regulations mentioned below. The PIEE elaboration model developed by ANRE and recognized by the Ministry of Energy was used, model used for the annual reporting of localities with over 5000 inhabitants. In this sense, there is a National Action Plan in the field of energy efficiency (PNAEE IV) and an integrated National Plan for energy and climate change, with clear and important objectives until 2030.

For the implementation of energy efficiency in Romania, there is Law no. 121/2014 on energy efficiency, with subsequent amendments and additions. The purpose of this law is to create the legal framework for the development and application of the national policy in the field of energy efficiency in order to achieve the national objective of increasing energy efficiency. Policy measures in the field of energy efficiency apply to the entire chain: primary resources, production, distribution, supply, transport and final consumption of energy.

Improving energy efficiency is a strategic objective of the national energy policy, due to its major contribution to the achievement of security of energy supply, sustainable development and competitiveness, to the saving of primary energy resources and to the reduction of greenhouse gas emissions.

A very important category among final energy consumers is represented by localities with more than 5.000 inhabitants, with the two components: public domain and residential domain. According to the provisions of the Energy Efficiency Law no. 121/2014, amended by Law no. 160/2016, at art. 9 paragraph (20) stipulates: “The local public administration authorities in localities with a population of more than 5,000 inhabitants are obliged to draw up energy efficiency improvement programs that include short-term measures and 3-6-year measures, with compliance with the provisions of art. 6 para. (14) lit. a) and b)”.

Reducing costs, consumption and increasing energy performance in buildings and energy use objectives are among the main objectives and priorities of the local public administration. By energy efficiency at the community level, we mean that determining factor for an intelligent, healthy and sustainable economic growth, with a major impact on the development of the VAMA commune, Suceava county.

Energy efficiency at the level of public, residential and private buildings means reducing the need and rational use of energy, at the same time as ensuring an adapted thermal comfort, indoor air quality and indoor lighting complying with the lighting standards in force.Through training and education actions in the field of efficient use of energy, the awareness and behavior change of the inhabitants of Vama commune in Suceava county is obtained.

As early as February 2015, the European Commission established its energy strategy through the Energy Union Package, which aims "to provide EU consumers - households and businesses - with secure, sustainable, competitive and affordable energy" and to achieve this they established five important pillars:

- supply assurance;
- expansion of the internal energy market;
- increasing energy efficiency;
- reducing emissions;
- research and innovation.

Legislation in Romania in the field of energy efficiency:

a) Law no. 121/2014 on energy efficiency;
b) HG no. 1069/2007 - Energy Strategy of Romania 2007-2020, updated for the period 2011-2020;
c) HG no. 1460/2008 - National strategy for sustainable development of Romania - Horizons 2013-2020-2030;
d) HG no. 122/2015 for the approval of the National Action Plan in the field of energy efficiency;
e) Ordinance no. January 13/27, 2016 for the amendment and completion of Law no. 372/2005 on the energy performance of buildings;

f) H.G. no. 129/2017 for completing art. 8 of Government Decision no. 1215/2009 regarding the establishment of the criteria and conditions necessary for the implementation of the support scheme for the promotion of high-efficiency cogeneration based on the demand for useful thermal energy

g) Law no. 184/20.07.2018 for the approval of GEO 24/2017 regarding the amendment and completion of Law no. 220/2008 for the establishment of the system for the promotion of energy production from renewable energy sources and for the modification of some normative acts

h) The strategy for mobilizing investments in the renovation of the stock of residential and commercial buildings, both public and private, existing at the national level.

By preparing this energy efficiency improvement study for UAT Vama, an energy diagnosis of the locality is actually carried out by establishing the energy management matrix, selecting the level corresponding to the situation in which the locality of Vama is at the time of the analysis, for each of the six criteria: energy policy, organization, commitment, information system, marketing, investments.

The energy efficiency improvement study can address an energy efficiency measure already implemented at the level of the respective locality or proposed for implementation, but the energy consumption before and after the implementation of the energy efficiency measure, the energy savings (estimated or achieved) in tons of oil equivalent must be highlighted (t.e.p), the investment recovery period and other relevant technical-economic indicators. The study ends with proposals, recommendations, observations regarding the improvement of energy efficiency regulations.

ELECTRICITY AND THERMAL ENERGY CONSUMPTION

Regarding the energy supply of the Vama commune in Suceava county, it only benefits from electricity supply. There is no natural gas supply network for Vama commune in Suceava county. The main source of thermal energy for heating and preparation of domestic hot water is biomass (firewood). Stove cylinders and firewood are used for food preparation.

Regarding the electricity consumption of the population, after questioning the residents, it was found that each home on record at the commune level has a consumption that depends on the month of the year, and the average monthly value is between 50 kWh and 100 kWh per month. In the calculations, an average monthly value, for each home, of 75 kWh/month/home, respectively 0.9 MWh/year/home, was considered. For the spaces belonging to the 82 legal entities, generally commercial spaces, an average monthly consumption of 200 kWh/month, respectively 2.4 MWh/year/commercial space, was taken into account. At the level of the commune, there are 2290 homes of natural persons.

№	Destination of electricity consumption	U.M.	Household	Non-household	Total
1	Population 2290 homes	Mwh	2061	-	2061
2	Public lighting	Mwh	-	136	136
3	Public buildings under the authority of the City Hall and the Local Council (pre-university, socio-cultural, administrative education units, public buildings with other purposes, etc.)	Mwh	-	143	143
4	Water supply	Mwh	0	-	0
5	Local public transport	Mwh	-	0	0
6	Consumption related to heat energy pumping	Mwh	0	-	0
7	Other unspecified consumers Legal entities 82 commercial companies and commercial premises	Mwh	-	197	197
	TOTAL UAT	Mwh	**2061**	**476**	**2537**
	TOTAL UAT	TEP	**177,246**	**40,936**	**218,182**

BIOMASS CONSUMPTION

In the commune of Vama, biomass in the form of firewood and pellets is used for heating and the production of domestic hot water.

For each individual home, among the 2220 of the population in the commune, an average amount of 25 sterile meters, i.e. 16.25 cubic meters of beech, with 700 kg per cubic meter, i.e. 11.375 tons of firewood consumed in a year for heating, was taken into account and domestic hot water for these homes. We also add the wood from over a year ago, approximately 1 meter ster, i.e. 0.65 cubic meters, which represents 455 kg dry, resulting in a total of wood for the individual home in the country, worth 11.83 tons.

For the 70 apartments in the building, an average amount of 16 sterile meters per year, i.e. 10.4 cubic meters of beech, with 700 kg per cubic meter, i.e. 7.28 tons of firewood consumed in one year for heating and possibly for part of the domestic hot water.

For the 82 spaces belonging to legal entities, an average amount of 25 sterile meters, i.e. 16.3 cubic meters, i.e. 11.38 tons of firewood, was taken into account for heating and preparing part of the domestic hot water.

For the commune of Vama, in 2019, only beech was consumed for heating and domestic hot water, for which the following energy characteristics were taken into account: 1 cubic meter of beech weighs 700 kg, which means 4.1251 kWh/kg x 700 kg /m^3 = 2,887.6 kWh/m^3.

A number of 19,500 cylinders of 12.5 kg each with liquefied gas (LPG) are consumed on the territory of the Vama commune. The energy capacity of these cylinders is approximately 244 tons/year x 12.5 MWh/t = 3050 MWh/year = 3050000 kWh/year = 262.3 tep/year.

№	Destination of consumption of biomass	U.M.	Total
1	Population at 2220 individual homes and 70 apartments per block	Tons	**26772**
2	Public buildings under the authority of the Local Council (pre-university, socio-cultural, administrative education units, public buildings with other purpose, etc.)	Tons	**403**
3	Other unspecified consumers – 82 buildings belonging to legal entities	Tons	**933**
	TOTAL	**Tons**	**28108**
	TOTAL	**TEP**	**9971,555**

FUEL CONSUMPTION (DIESEL, GASOLINE, COMPRESSED NATURAL GAS)

Within the commune of Vama, there is currently a minibus for transporting students back and forth to school. Existing minibuses use diesel. The following table shows the breakdown of fuel consumption at the commune level for 2019.

№	Destination of fuel consumption	U.M.	Diesel fuel	Petrol	Com-pressed natural gas	Electricity (Electric buses)	Electricity (traction)	Total (tep)
1	Local public transport for students	Tons	4,038	0	0	0	0	4,10
2	Public sanitation service	Tons	0	0	0	0	0	0
3	Other means of transport and machinery	Tons	15,902	0	0	0	0	16,14
4	Car	Tons	0	2,178	0	0	0	2,27
5	Chainsaws and tines	Tons	0	1,836	0	0	0	1,93
	TOTAL	**Tons**	**19,940**	**4,014**	**0**	**0**	**0**	**24,44**

Conclusions of the Energy Efficiency Improvement Program (EEIP):

1. The total amount of energy consumed in 2019 throughout the Vama commune was 10476.477 tep;
2. The share of energy fluids in the total energy consumed in 2019 was as follows:
- firewood – 95,19%;
- stove cylinders – 2,50%;
- electricity – 2,08%;
- diesel fuel – 0,19%;
- petrol – 0,04%.

3. More than 90% of the total energy consumed at the level of Vama commune in Suceava county in 2019 was for heating homes and public or private spaces where activities with people are carried out.

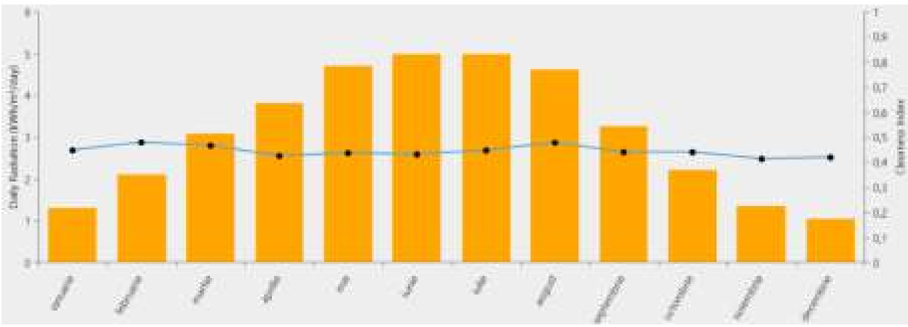
So, the biggest reserve for increasing energy efficiency is to reduce the consumption of firewood, but without affecting people's comfort. This objective can be achieved mainly in two ways:

- increasing the energy efficiency of heated building envelopes;
- replacement of heating systems, with modern splints with high energy efficiency.
- Examples of possible objectives of the energy efficiency improvement program:
- reducing total energy consumption in public buildings by 15% until 2025 by modernizing and increasing interior comfort;
- reducing electricity consumption by 15% in public buildings until 2025;
- reducing the specific energy consumption per square meter in public buildings by 30% until 2030.

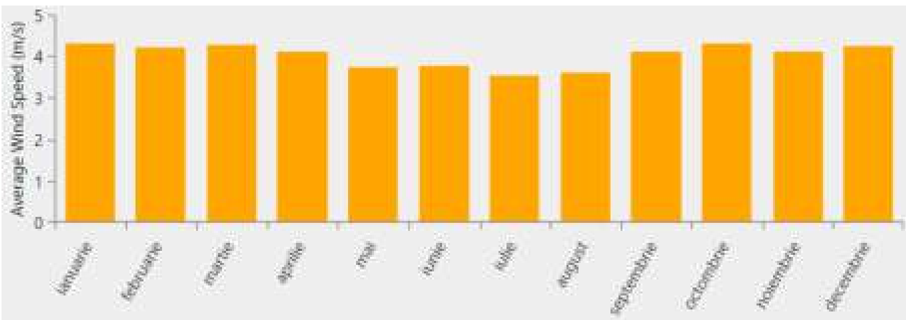
III. RECOMMENDATIONS ON INCREASING ENERGY EFFICIENCY (BEST SOLUTIONS)

In the following, a series of solutions for the supply of electricity from renewable sources proposed by the experts from the project implementation team for the Vama commune are presented. These measures are related to the increase of energy efficiency in the buildings managed by the Vama town hall. The implementation of renewable energy sources is possible for all 12 buildings managed by the local community. The simplest measure to implement refers to photovoltaic sources that can be integrated into the structure of buildings or mounted and exploited using a neighboring land area. The disadvantage of the implementation of these photovoltaic sources boils down to the climatic conditions in the North-East area, which are not comparable, for example, to those in the South of Romania. However, the use of photovoltaic panels as a source of electricity production should not be excluded, but rather recommended.

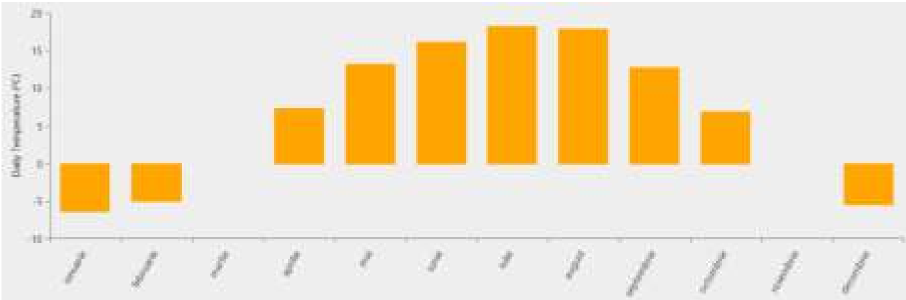
In the following, some aspects are presented regarding the implementation of photovoltaic sources on the building of the kindergarten in Molid and the building of the Vama City Hall, considering the specific climatic conditions. The Vama commune region is characterized by moderate values of solar irradiance (and clarity indices), temperature and wind speed, as can be seen from the following representations. Clarity indices describe the level of clarity of the atmosphere that may contain dust, traces of pollution, water vapor. The average value of the solar irradiance is 3.13 kWh/m2/day, and that of the wind speed is 4 m/s, while the average daily temperature value in the Vama region is 6.3 °C.



Average monthly value of solar irradiance in the Vama region



Average daily values of wind speed in the Vama region



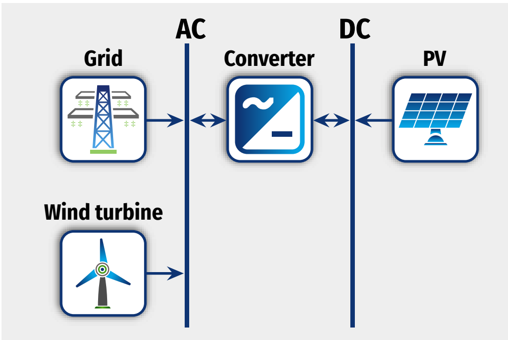
Average daily temperature values in the Vama region

1. Kindergarten with normal program Molid, Vama commune. Implementation of hybrid electricity production system

According to existing data, the electricity consumption of the Molid kindergarten with a normal program is 7.32 MWh/year. In order to compensate for this amount of electricity, it is recommended to install photovoltaic panels on the roof of the building with a total installed power of 10 kW, specifying that the roof surface of the Molid kindergarten with normal program allows the installation of approximately 30 photovoltaic panels. The use of a wind turbine represents an alternative for compensating the electricity taken from the grid.

Kindergarten with normal program Molid.
Geographical location

Thus, it is proposed to implement a hybrid photovoltaic system for the production of electricity consisting of photovoltaic panels and, in parallel, a low-power wind turbine. The operation block diagram of the on-grid photovoltaic system includes a photovoltaic source with an installed power of 10 kW, a wind turbine with a nominal power of 1 kW and an inverter for transferring the energy produced to the network, according to the operation block diagram.



Functional block diagram of the hybrid power generation system.
Molid Kindergarten

For the analysis of the operation of the on-grid photovoltaic system, the following were established:

1. Photovoltaic panels are mounted on the roof of the building, which excludes the use of an orientation system. The tilt angle for the panels was set to 47°.

2. Ground reflection losses are eliminated by mounting photovoltaic panels on the roof of the building.

3. The effect of temperature (-0.470 %/°C) on the power produced by the PV panels, the efficiency of the panels given by the manufacturer under standard test conditions (20%) and the standard operating temperature of the PV cell (47°C) were taken into account.

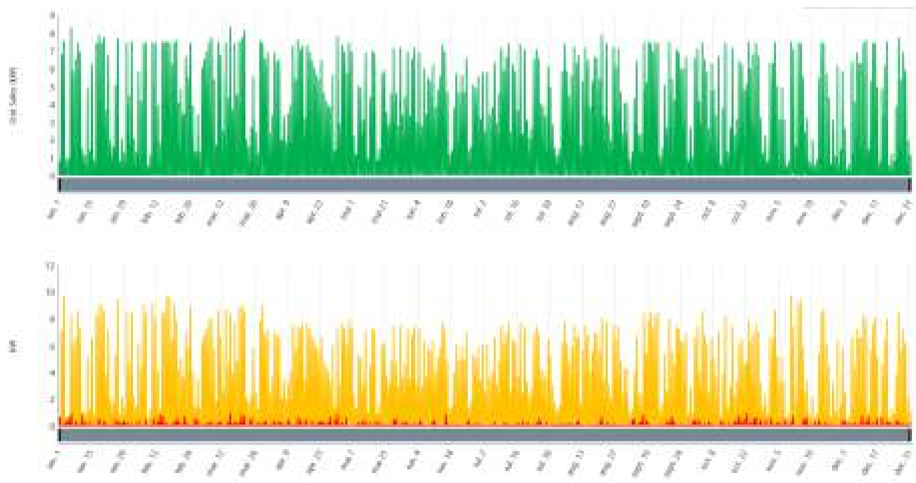
The results obtained from the modeling highlight a series of characteristics of the system made up of renewable sources, centralized in the following table.

Photovoltaic system characteristics		
The amount of energy produced annually	**11064**	**kWh/year**
Average energy produced in a day	30,3	kWh/day
Maximum power produced	9,75	kW
Capacity factor	12,6	%
Hours of operation	4374	Hour/year

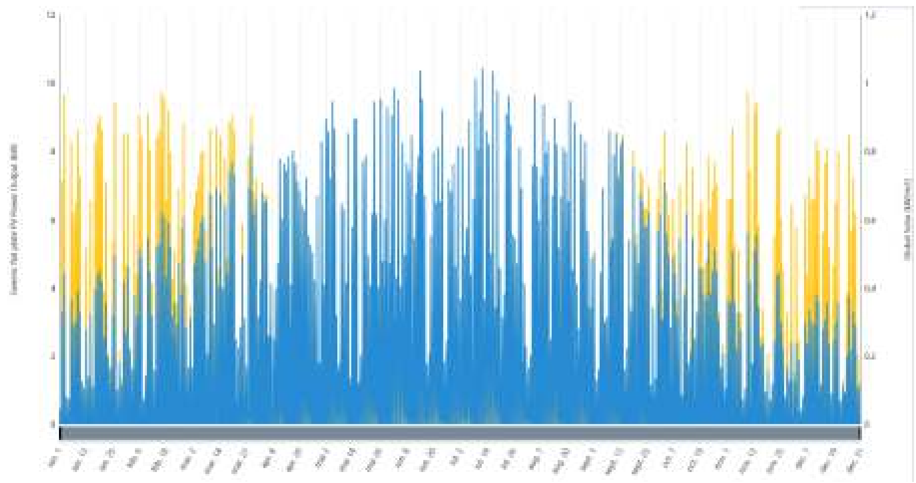
Wind turbine characteristics		
The amount of energy produced annually	**311**	**kWh**
Capacity factor	3,56	%
Hours of operation	4920	Hour/year
Maximum power produced	0,946	kW
Average power produced	0,0356	кВт

Electric energy injected into the power grid		
January	768	kWh
February	856	kWh
March	1053	kWh
April	956	kWh
May	1041	kWh
June	996	kWh
July	1030	kWh
August	1061	kWh
September	913	kWh
Octomber	807	kWh
November	638	kWh
December	643	kWh
TOTAL	**10761**	**kWh**

Through the operation of the photovoltaic system and the wind turbine, a quantity of electricity worth 10761 kWh/year will be injected into the electrical network. The figure below illustrates the variation of the power injected into the electrical network as an effect of the power produced by the two renewable sources (photovoltaic and wind). Afterwards, the power generated by the on-grid photovoltaic system is represented in relation to the distribution of solar irradiance (global component).



The electric power injected into the network and the power produced by each source, in a year. Molid Kindergarten



The power produced by the on-grid photovoltaic system in relation to solar irradiance. Molid Kindergarten

The operation of the wind turbine in the Vama region can be analyzed by the wind speed distribution, shown next. It is found that the wind turbine will operate at 95% of the nominal power only at a few moments in a calendar year. Otherwise, the average power produced is limited to around 300 W, due to the rather modest wind speed values.

The power produced by the wind turbine in relation to the wind speed.
Molid Kindergarten

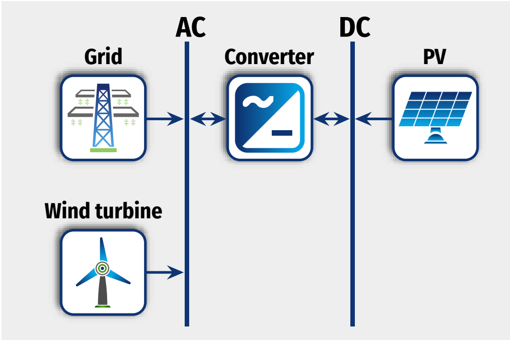
Conclusions. By implementing a hybrid electricity production system with a total installed power of 11 kW, the Kindergarten building in Molid can cover its electricity consumption of 7.320 kWh/year. The installation of a wind turbine is optional as it brings a maximum power input of 3% of the total 10.761 kWh/year due to unfavorable wind conditions.

2. Vama City Hall. Implementation of hybrid electricity production system.

According to existing data, the electricity consumption of the Vama City Hall building is 15.73 MWh/year. And in this case, to compensate for this amount of electricity, it is recommended to install photovoltaic panels on the roof of the building with a total installed power of 16 kW and a wind turbine as a secondary source of electricity production. The project proposes the creation of a hybrid on-grid photovoltaic system for the production of electricity consisting of photovoltaic panels and a low-power wind turbine.

Vama City Hall building. Geographical location

The operating block diagram of the on-grid photovoltaic system is the same and includes a photovoltaic source with an installed power of 16 kW, a wind turbine with a nominal power of 1 kW and an inverter for transferring the energy produced to the network, according to the operating block diagram.



Functional block diagram of the hybrid power generation system.
Vama City Hall

For the analysis of the operation of the hybrid electricity production system, the same assumptions were considered as for the kindergarten building in Molid:

1. Photovoltaic panels are mounted on the roof of the town hall at an angle of inclination of 47°.

2. The effect of temperature (-0.470 %/°C) on the power produced by the PV panels, the efficiency of the panels given by the manufacturer under standard test conditions (20%) and the standard operating temperature of the PV cell (47°C) were taken into account.

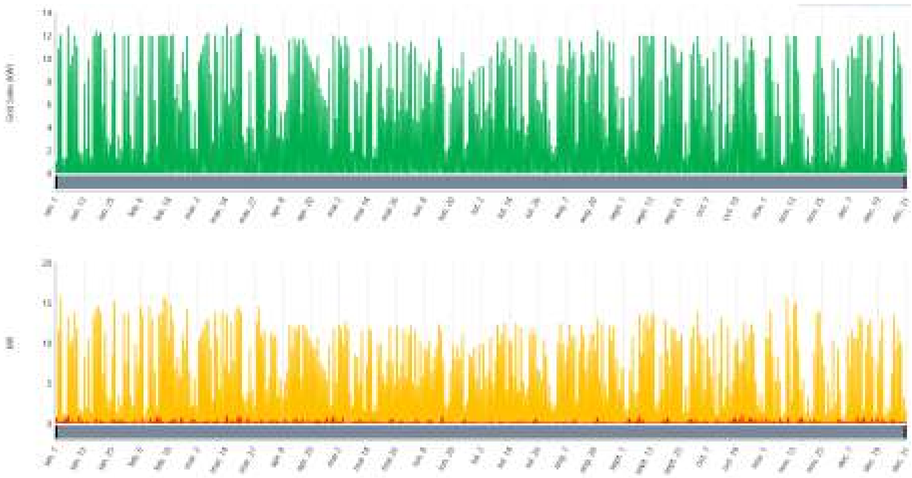
The obtained results highlight a series of characteristics of the system made up of renewable sources, centralized in the following table.

Photovoltaic system characteristics		
The amount of energy produced annually	**17702**	**kWh/year**
Average energy produced in a day	48.5	kWh/day
Maximum power produced	15.6	kW
Capacity factor	12.6	%
Hours of operation	4374	hour/year
Wind turbine characteristics		
The amount of energy produced annually	**311**	**kWh/year**
Capacity factor	3,56	%
Hours of operation	4920	hours/year
Maximum power produced	0,946	kW
Average power produced	0,0356	kW

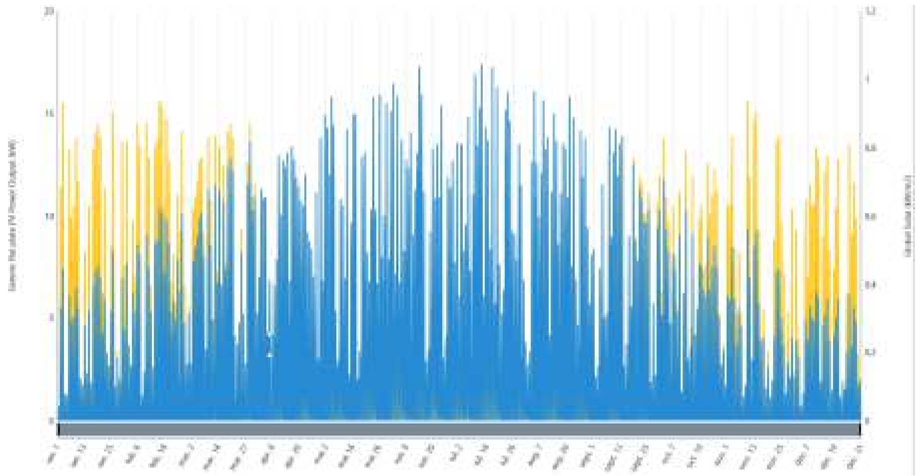
The obtained results highlight a series of characteristics of the system made up of renewable sources, centralized in the following table.

Electric energy injected into the power grid		
January	1210	kWh
February	1355	kWh
March	1666	kWh
April	1513	kWh
May	1654	kWh
June	1583	kWh
July	1639	kWh
August	1688	kWh
September	1445	kWh
Octomber	1270	kWh
November	1005	kWh
December	1009	kWh
TOTAL	**17037**	**kWh**

The image below shows the distribution of the power produced by the two renewable sources (wind and photovoltaic) in a year simultaneously with the variations of the two electric powers generated by the photovoltaic panels and the wind turbine.



The electric power injected into the network and the power produced by each source, in a year.
Vama City Hall



The power produced by the on-grid photovoltaic system in relation to solar irradiance. Vama City Hall

If we refer only to the power of the photovoltaic system, a variation is found according to the distribution of solar irradiance in the analysis area, specifying that during the cold season the temperature drops, which leads to an increase in the power produced by the photovoltaic panels. This fact can be seen in the image above.

Conclusions. By implementing a hybrid electricity production system with a total installed power of 16 kW, the City Hall building in Vama commune can cover its electricity consumption of 15.730,00 kWh/year. The installation of a wind turbine is optional as it brings a maximum power input of 2% of the total 17.037,00 kWh/year due to unfavorable wind conditions.

3. The possibility of implementing alternative energy systems of high efficiency for the building KINDERGARTEN WITH NORMAL PROGRAM SPRUIT, Vama

According to Law no. 372/2005 on the energy performance of buildings (updated in 2020), a building can be considered nZEB if the energy requirement from conventional sources is very low and is covered as follows:

a) in proportion of at least 30%, with energy from renewable sources, including energy from renewable sources produced on site or nearby, within a radius of 30 km from the GPS coordinates of the building, starting in 2021;
b) minimum proportions of energy from renewable sources, including renewable energy produced on-site or nearby, within a radius of 30 km from the GPS coordinates of the building, for the periods 2031-2040, 2041-2050 and after 2051, are established by Government decision.

In the reference scenario, the primary source of energy that provides the building's utilities (heating, cooling, ventilation, domestic hot water and lighting) is represented by electricity purchased from the public grid. Heating and domestic hot water are provided by an own thermal power plant operating on electricity and the cooling (air conditioning) requirement is provided by a split type air conditioning system (COP=3). The equivalent primary energy consumption and carbon dioxide emissions for the reference scenario, taking into account the conversion factors for electricity purchased from the public grid, are presented below.

The primary source of energ	Energy requirement [kWh/year]	Conversion factor	Equivalent primary energy consumption [kWh/year]
Electrical energy	25.637,10	2.62	67.169,19
Greenhouse gas emissions [kgCO_2/year]			5.870,90
CO_2 equivalent emission index [kgCO_2/m^{2}an]			28.73

In the present study, several alternative possibilities for providing utilities in the building (heating, cooling, domestic hot water, lighting and electrical appliances) are analyzed, compared to the reference scenario presented above. The following scenarios are analyzed:

- Scenario 1: photovoltaic panels;
- Scenario 2: thermal solar panels;
- Scenario 3: heat pump;
- Scenario 4: thermal plant with gasification.

Scenarios 1 and 2 consider the possibility of covering part of the building's energy needs with solar energy. Solar energy can be converted directly into electricity through photovoltaic panels or into heat through solar thermal panels.

In this alternative scenario, an on-grid photovoltaic panel system (connected to the public grid) with an installed electrical power of 5 kW was considered for the designed building. The system is all the more profitable as the electricity production will be used predominantly for self-consumption. The delivery (sale) of surplus electricity in the public network is currently done at a rate of approximately 50% of the purchase rate. Thus, the tariff for the sale of electricity in the network is regulated by ANRE order and is published on the OPCOM website. The weighted average price recorded on the market for the next day in 2021 was 0.550 lei/kWh. According to the Methodology approved by ANRE Order no. 15/2022 prosumers with installed power below 200 kW can benefit from the quantitative compensation mechanism until December 31, 2030. Therefore, the sizing of the photovoltaic system must take these aspects into account, i.e. the electricity production must be predominantly used for self-consumption

For the solar thermal panel system, a system with a maximum thermal power of 15 kW was considered, which can provide the maximum energy requirement for domestic hot water but which can also provide part of the heating requirement.

The annual productions of electricity and thermal energy respectively are presented in the following table.

Utility	Estimated production [kWh/year]	Coverage percentage from renewable sources
Electricity (Scenario 1)	7,872	30,71%
Thermal energy (Scenario 2)	9,840	38,38%

In scenario 3, the possibility of using heat pumps is considered. The heat pump extracts heat from the air, soil or water in winter, and then, with the help of a compressor mounted inside, the refrigerant is heated to a higher temperature. In summer, the cycle reverses and the house is cooled. The principle of the water-to-water heat pump is to extract water from the water table, usually with a constant temperature of 12-14 °C. In order to capture the energy from the water table, at least two boreholes are needed, one for extraction and the other for discharging the water from the heat pump. The ground-to-water heat pump extracts heat from the ground and usually requires a larger surface area of the catchment area. The air-to-water heat pump extracts heat from the surrounding environment. In this scenario, a system with an air-to-water heat pump of 35 kW, COP=3.65 was considered.

For the analyzed heat pump, the results are presented in the following table.

COP	Energy saving [kWh/year]	Energy saving [%]
3,65	17.082,14	66.63%

In scenario 4, a thermal power plant with gasification is considered as the primary energy source. The thermal power plant operates on wood fuel (cut and very well dried pieces of wood, with as low a humidity as possible, preferably below 15%). Gasification is the process by which flammable gases such as hydrogen, carbon monoxide, methane and some non-flammable products are produced. The whole process takes place by partially burning and heating the biomass with the heat generated during combustion.

The principle of wood gasification or wood distillation involves the introduction of solid fuel into the upper room of the plant, i.e. in the wood shed of the plant, in contact with the embers produced on the grill, giving rise to gases that combine with air to create a mixture. This mixture is drawn through the slits of the grate into the lower area of the firebox which is also called the exchange area, where it will create the inverted flame or reverse flame. Gasification does not mean the direct burning of wood, but the gases contained in it, allows a complete combustion of the solid fuel, which means a high combustion efficiency.

In order for the biomass consumed to be considered a renewable source of energy, it must be certified, that is, it must come from a source with guarantees of origin. The impact on the environment in the case of the proposed alternative scenarios is quantified by the reduction of greenhouse gas emissions, presented in the following table.

Scenario	Reducing carbon dioxide emissions [kgCO_2/year]
S1. Photovoltaic (PV) panels	2.353,73
S2. Solar thermal panels (STP)	2.942,16
S3. Heat pumps (HP)	5.107,56
S4. Biomass boiler with gasification (BBG)	1.365,01
S5. Hybrid system S1+S3 (PV+HP)	7.461,29
S6. Hybrid system S2+S4 (STP+BBG)	4.307,17

The results of the cost-benefit analysis, for the alternative scenarios analyzed, are presented in the following table.

Scenario	The difference in investment expenses [EUR]	Annual economy [EUR/year]	Recovery time [years]
S1. Photovoltaic (PV) panels	14400	1968	7,32
S2. Solar thermal panels (STP)	12000	2460	4,88
S3. Heat pumps (HP)	27650	4271	6,47
S4. Biomass boiler with gasification (BBG)	8100	1461	5,54
S5. Hybrid system S1+S3 (PV+HP)	42050	6239	6,74
S6. Hybrid system S2+S4 (STP+BBG)	20100	3921	5,13

The data in the following table, for the annual economy, were obtained for the following tariff values: electricity 0.25 EUR/kWh; biomass (firewood) 0.1 EUR/kWh.

CONCLUSIONS AND RECOMMENDATIONS

ll analyzed alternative energy production solutions are technologically mature and can be considered by the beneficiary. The first two solutions, due to the intermittent nature of the energy production from the solar source but also the lower energy production in the cold season when the energy consumption in the building is the highest, are recommended to be considered in combined (hybrid) systems such as scenarios 5 and 6.

In conclusion, all the analyzed alternative energy production solutions are viable both technically and economically and from the point of view of environmental impact and can be easily adopted by the beneficiary.

IV. RESOURCES FOR IMPLEMENTING THE BEST ENERGY EFFICIENCY SOLUTIONS IN VAMA COMMUNE

1. In the commune of Vama, through the commune's Strategy for 2019-2029, a modernization and energy efficiency project is foreseen in the future with the title **Valorification of green, renewable energies**, as well as environmental protection and reduction of carbon emissions. The funding sources considered are: ERDF (POR 2014-2020), the Norwegian Fund, local budget, national budget (AFM) and other legally established sources.

Among the project's objectives are the sustainable use of natural resources and the reduction of greenhouse gas emissions, by capitalizing on renewable energy sources (photovoltaic, geothermal) and reducing utility costs.

This project envisages the installation of photovoltaic panels on public lighting systems and traffic control panels, the provision of buildings of public interest owned by the municipality with installations for the production of energy from renewable sources (solar, hydro) and the organization of actions of awareness regarding the benefits of using **“green energy”**.

2. At the current stage, several financing programs for investments in renewable energy sources are underway, however, for UAT Vama, the financing program for small and medium-sized enterprises and the HORECA field **“ElectricUp”** is of interest. It is a funding program coordinated by the Ministry of Energy. Small and medium-sized enterprises and the HORECA field are financed, regarding the installation of photovoltaic panel systems for the production of electricity with an installed power between 27 kWp - 100 kWp necessary for own consumption and the delivery of the surplus to the National Energy System, as well as recharging stations minimum 22 kW for electric and plug-in hybrid electric vehicles.

For this financing program, the entities within the radius of Vama commune in Suceava county, namely the approximately 80 legal entities, most of which are from the HORECA industry, but also for the other IMMs, are eligible.

The non-refundable financing is granted in the amount of a maximum of 100.000,00 euros for the installation of photovoltaic panel systems for the production of electricity with an installed power of 100 kWp and at least one recharging station of a minimum of 22 kW for electric and plug-in hybrid electric vehicles, with at least two charging points, representing a financial support of up to 100% of the eligible expenses.

3. The program regarding the installation of photovoltaic panel systems for the production of electricity, in order to cover the consumption requirement and deliver the surplus to the national network (https://www.afm.ro/sisteme_fotovoltaice.php).

Domestic consumers are eligible, namely the more than 2000 individual houses, which can access such non-refundable funds. Financing is granted in percentage of up to 90% of the total value of eligible expenses, within the limit of 20000 lei. The minimum installed power of the photovoltaic system for which financing is requested is 3 kW. The program is coordinated by the Environment Fund Administration (AFM).

4. LARGE INFRASTRUCTURE OPERATIONAL PROGRAM (POIM) 2014-2020.

Projects to support investments in energy production capacities from renewable energy sources, for own consumption.

The measures for the production of energy from renewable sources intended for local public administration authorities aim to promote investments in the clean energy sector and energy efficiency in order to ensure the contribution to the objectives regarding the final consumption of energy from renewable resources.

The main objectives of the project:

- economy more efficient from the point of view of the use of sources, greener and more competitive, leading to sustainable development, which is based, among other things, on a high level of protection and on improving the quality of the environment, as part of the Europe 2020 Strategy;
- achieving the objectives of the European Union regarding the production of energy from renewable sources provided for in Directive (EU) 2018/2001 of the European Parliament and of the Council on the promotion of the use of energy from renewable sources;
- increasing energy production from renewable sources;
- increasing the share of renewable energy in the total primary energy consumption, as a result of investments to increase the installed power of producing electricity and thermal energy from renewable sources;
- reduction of carbon emissions in the atmosphere generated by the energy sector by replacing part of the amount of fossil fuels consumed each year - coal, natural gas.

UAT Vama can access the following types of projects:

- Realization of the production capacities of electricity and/or thermal energy in cogeneration from renewable energy sources, with the exception of biomass for own consumption;
- Realization of electrical or thermal energy production capacities from renewable energy sources with the exception of biomass for own consumption.

By own consumption is meant the consumption related to public buildings owned and occupied by the local public authorities and institutions, as well as the consumption related to the public lighting sector, under the direct administration of administrative-territorial units.

Production capacities from renewable energy sources for own consumption must be sized in accordance with the analysis of the authorized expert strictly for the consumption needs of public buildings owned and occupied by local public authorities and institutions, as well as that related to the public lighting sector, at the time of receipt of the analysis energetic.

It is possible to invest in equipment, machinery, specific equipment needed to obtain energy from renewable sources intended for the local public authorities' own energy consumption. The use of renewable energy sources includes photovoltaic panels, the use of geothermal water, the use of wind energy in areas where there is potential for the use of wind energy. Within this type of project, there may be expenses related to the creation, purchase, modernization of units, new/existing cogeneration, trigeneration capacities for obtaining heat and electricity in cogeneration from renewable sources, including energy distribution networks.

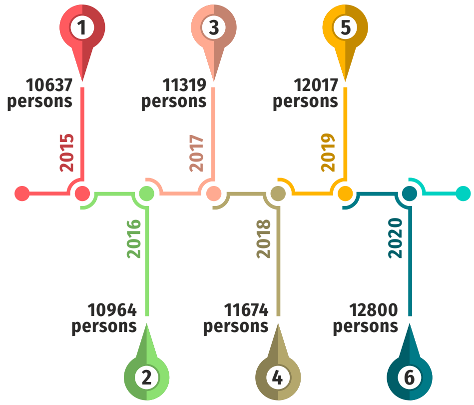
5.3 ŞCHEIA COMMUNE

I. General presentation. Current situation and challenges.

The commune of Şcheia is located in the area of influence of the city of Suceava, being a suburban commune. Șcheia commune (https://www.primariascheia.ro) is located in Suceava county and from an administrative point of view, it is made up of 5 villages: Florinta, Mihoveni, Șcheia, Trei Movile, Sfântu Ilie. The village of Şcheia is the residence of the commune. The local public administration authorities, the police, the humane dispensary, the veterinary dispensary, the general school with classes I-X are located in the village-communal residence. The population of Șcheia commune amounts to 9.577,00 inhabitants, with a density of 164 inhabitants/sq.m.

Overview of Şcheia commune, Suceava county

The increase or decrease of the population is one of the indicators that reveal the economic situation of a community, the dynamics of the population indicating the economic evolution of a locality. The population dynamics of the Șcheia commune, according to the statistical data recorded in the period 2015-2020, is presented as follows:



Population dynamics until 2020

According to these data, it can be seen that the population of the commune had an upward evolution in the period 2015-2020, a fact also determined by the positioning adjacent to the Suceava Metropolitan Area.

The distribution of the number of inhabitants in Şcheia commune

Şcheia commune is located in the eastern part of Suceava county, in the immediate vicinity of Suceava Municipality. Şcheia commune is bordered by the following territories: to the north, Pătrăuți commune and Dărmănești commune, with the Suceava river as its natural border; to the South-West and West Stroiesti commune; to the North-West Todirești commune; to the East the municipality of Suceava; to the South, Moara commune. The area of the commune belongs to a plateau relief, from a geomorphological point of view it falls within the Moldova Plateau unit, the Sucevei Plateau subunit, the northern part of the Fălticeni Plateau subunit.

The territory of the commune is located morphologically in the platform area of the Suceva Plateau (subunit of the Fălticeni Plateau) whose relief began to emerge from the Lower Sarmatian (Volhinian), with the retreat of the waters of the Sarmatic Sea towards the SE. The valleys are asymmetric of consistent type. The slopes are generally smooth, with small slopes, with lengths of 2 - 4 km and widths of 2 - 3 km. North-facing slopes are affected by landslides. The relief of the area consists of small structural plateaus, through hilly and hilly forms, slightly inclined in the direction of the geological structure, as well as through wide valleys.

The relief can be divided into three subunits:

- the northwestern part represented by Dealul Mare (453 m) and Dealul Teișorului (528 m), between the Suceava river and the Șcheia stream;
- the central part, represented by the valley of the Şcheia stream, with its meadow and terraces;
-the southern part represented by Ciritai Hill (453 m) and Crucii Hill (428 m).

From an altimetric point of view, the territory of the commune of Șcheia culminates on the Teişorul Hill with an altitude of 528 m, located in the northwest of the territory and descends downstream from the Suceava Valley to 270 m. Between these values, a series of intermediate hills consisting of peaks can be distinguished, which have heights of 453 m in Ciritai Hill and 427 m in Crucii Hill. The Suceava Valley is along almost its entire length at altitudes below 300 m. The average altitude of the relief oscillates around 400 m, and the maximum altitude reaches 528 m.

The hydrographic network. The commune of Șcheia is crossed by the river Suceava, on the north-east side of the territorial-administrative boundary, belonging to the hydrographic basin of the river Siret.

The network is completed by the following running waters:
- Şcheia, Şcheianu, Frumoasa and Hăleşteu streams in the area of Şcheia and Sf. Ilie villages;
- Săliştea and Ciot streams in the Mihoveni village area.

When the snow melts and during floods, small water courses are formed that become tributaries of the streams, in the areas of Podul Bulii, Frumoasa, Fânețiii, Răzușca, Săliștea.

From a hydrological point of view, the territory of Şcheia Municipality falls within the Moldavian Plateau area, which differs from the other areas, through a more accentuated continental hydrological regime with rainwater predominating, characterized by large spring waters and intense rainstorms during summer and autumn. Runoff in winter is low (mainly underground supply).

Climate. The climate in the area where Șcheia Commune is located has a temperate continental character, with excessive nuances, with frosty winters and hot summers, sometimes with prolonged periods of drought.

The predominant air masses are the Baltic and Scandinavian continental ones, and to a lesser extent the oceanic-Atlantic and Mediterranean ones. The average annual temperature at the Suceava weather station is 7 - 8°C, showing:

-average temperature of July: 18.5°C
-average temperature of January: -4°C.

The absolute maximum temperature recorded is +39.6°C (on August 16, 1954) and the absolute minimum temperature recorded is -31°C (on February 20, 1954), in this context resulting in a value of the absolute thermal amplitude of 70.6°C. These large thermal differences are the result of the combined action of solar radiation, the circulation of air masses and the characteristics of the active surface in the area of the Suceava valley. These temperature extremes can have a decisive influence on agricultural crops of any kind. Thus, in the cold season, if the ground is not covered with snow, autumn crops can be destroyed by frost, and in the warm season, high temperatures lead to drought.

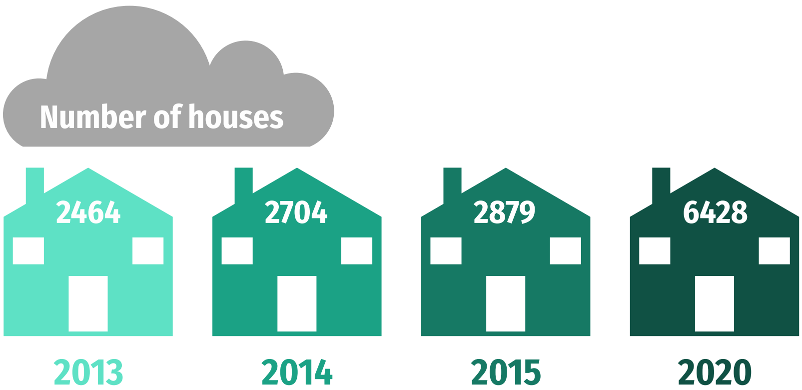
The lowest amount of precipitation is recorded in January, and the maximum in June. The rainiest months are the summer months with 45% of the total amount of precipitation falling in a year. The end of autumn, winter and the beginning of spring (October - March) are characterized by small amounts of precipitation that represent only 25% of the total.

Winds. Wet or dry, warm and cold winds accentuate the differences in humidity and air temperature. The winds in this area are oriented along the Suceava river valley.

In the Şcheia commune, the winds blow most frequently, according to the Suceava station, from west and northwest, producing frontal precipitation. The dominant wind is from the western sector, with an annual frequency of over 25%. Winds from the eastern sector register a higher frequency in spring. The winds from the north are conditioned by the Azores Anticyclone and have a much lower intensity in this area. Winds from the south have a frequency of 8%. The highest wind speeds are frequently recorded in spring and winter, and the lowest average monthly speeds are recorded towards the end of summer and the beginning of autumn, in the months of July-September.

Housing stock. The habitat of the Șcheia commune, consists mostly of houses on the ground floor, P, and the constructions in the central area and the most recent ones are of type P+1, P+2, there are also blocks of flats P+3, P+ 4, P+8.

According to the statistical data provided by the town hall of the Șcheia commune, in recent years we have witnessed a galloping increase in the housing stock, from a number of 2464 in 2013 to 6428 registered homes in 2020. These data provide us with important information regarding the state socio-economic development and at the level of residents' perception of the zonal potential.



Theevolution of the housing stock of the commune of Şcheia until 2020

Seven preschool education units operate on the territory of Şcheia municipality:

-Two kindergartens in the Şcheia commune;

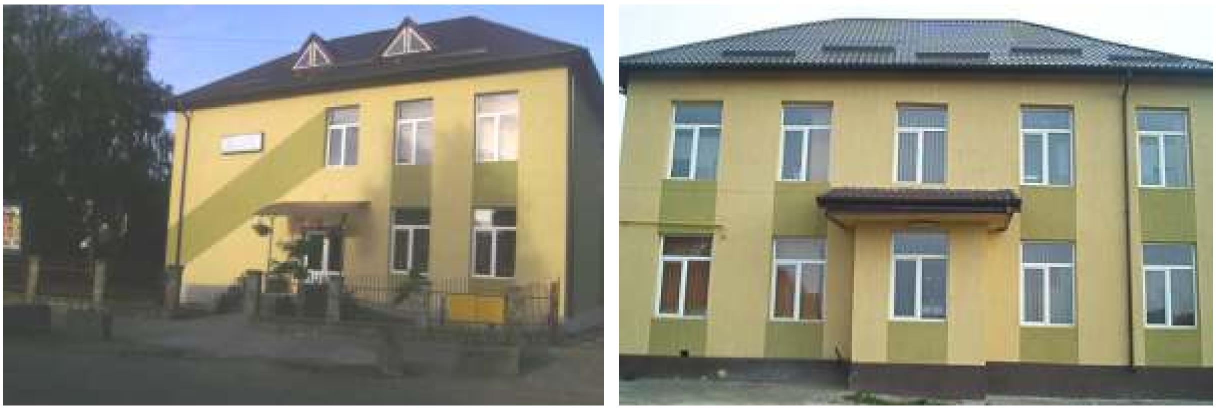
-A kindergarten in the village of Mihoveni;

-Four kindergartens in the village of Sf. Ilie;

-School with classes l-VIII “Dimitrie Păcurariu” Şcheia;

-School with grades l-VIII “Niculae Popinceanu” Mihoveni;

-The school with classes I-VIII Sf. Ilie.



School with grades I-VIII "Dimitrie Păcurariu", Şcheia commune

School with grades I-VIII “Niculae Popinceanu” Mihoveni, Şcheia commune

School with grades I-VIII St. Ilie, Şcheia commune

Water supply network. In the commune, the water supply in a centralized system exists in the localities of Șcheia and Sf. Ilie, from the water supply network of the municipality of Suceava (ACET), through a connection from the pipe that supplies the industrial area of the city and which brings the water to an intermediate reservoir. From here, through a pumping station, the water is sent to consumers and to the storage tank.

In 2008, the municipality of Șcheia commune started the *Centralized Water Supply project* in the town of Mihoveni, Șcheia commune, Suceava county, financed by PNDR, in a total amount of 560,000 lei with a contribution from the local budget of 110.000,00 lei, a project which is to be completed during 2021. The water supply of the population that does not benefit from the centralized system is provided from its own sources, wells dug from wells fed from the water tables.

Electricity supply. The electricity supply of the Şcheia commune is ensured from the medium voltage network, connected to the National Energy System. The electrical and street lighting networks are continuously expanding, to ensure the connection of the new homes.

Supply with heat and natural gas. The communities of Şcheia and Sf. Ilie are connected to the natural gas network of the municipality of Suceava. In the localities of Mihoveni, Florinta and Trei Movile there is no natural gas supply, heating is mostly done with solid fuel stoves (wood, agricultural waste, etc.).

In this sense, the municipality of Șcheia commune has started the steps to submit the project of "Establishment and expansion of the natural gas distribution system", financed by the Large Infrastructure Operational Program, which aims to establish networks in the villages of Mihoveni, Florinta and Trei Movile, as well as the expansion of the gas distribution network natural in Şcheia and Sf. Ilie.

The implementation of measures to increase energy efficiency in the Şcheia commune

In the period 2021-2027, Romania will benefit from non-refundable community financial assistance for the development of European territorial cooperation programs and projects, aiming at the balanced development of the entire territory by encouraging cooperation and the exchange of best practices between all regions of the European Union.

From the socio-economic development strategy of the municipality of Şcheia, the action plan 2021-2027, the **Cross-border Cooperation Program Hungary-Slovakia-Romania-Ukraine INTERREG NEXT 2021-2027, PO2, A Greener Europe/TO1 - P1 Environment**, with the thematic objective: Environmental protection, mitigation and adaptation to climate change and priority 1: Sustainable use of the environment in the cross-border area - conservation of natural resources, actions to reduce greenhouse gas emissions and river pollution.

Anticipated results will be determined by:

- an increased capacity in the programming area to address challenges in the field of environmental protection and climate change mitigation;

- an increased capacity in the programming area to address challenges in the field of environmental protection and climate change mitigation;
- the successful protection of common natural values by demolishing the effects of borders on habitats and increasing the awareness of people living in the area;
- improving the water quality of rivers that cross borders as a result of interventions related to waste management and wastewater treatment;
- increasing awareness, competence and skills in the field of renewable energy technologies and energy efficiency interventions among citizens, businesses and institutions;
- as a final result, less dependence on imported energy sources in the programming area.

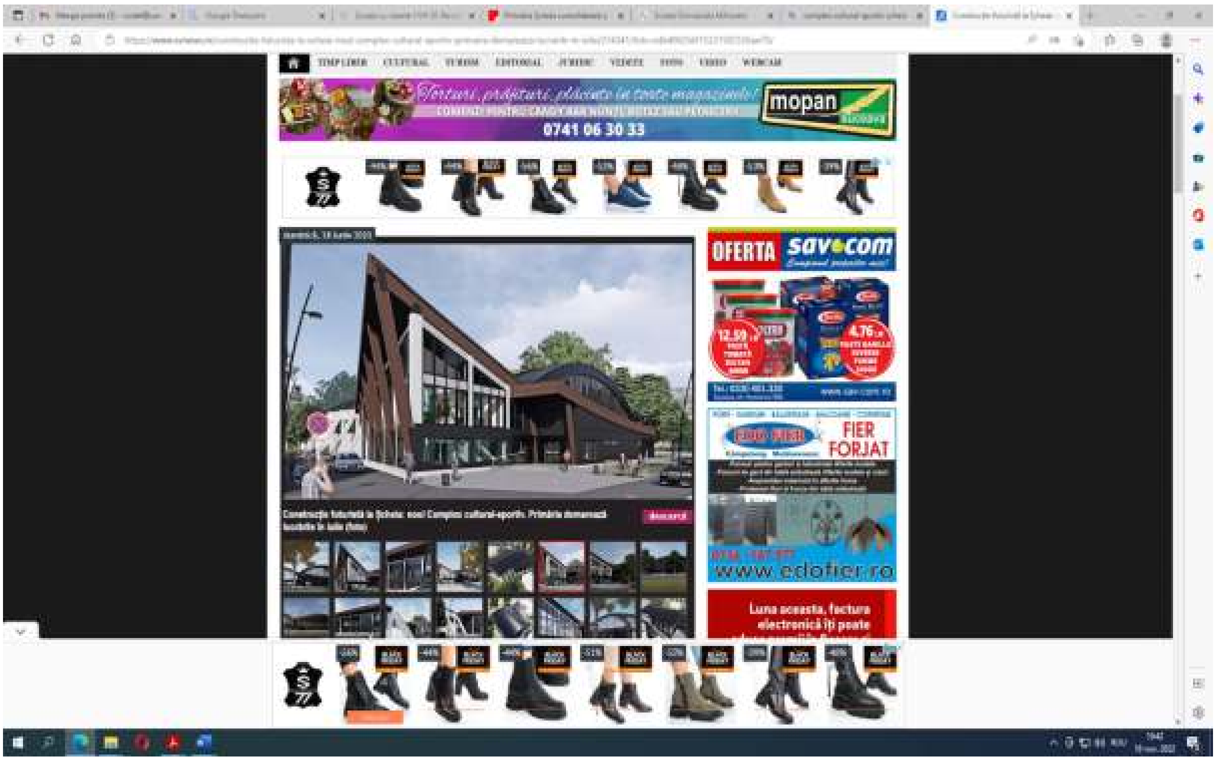
In the same 2021-2027 programming period, a series of specific objectives can receive funding under the **RO-UA Program**:

- Promoting energy efficiency and reducing greenhouse gas emissions;
- Promotion of renewable energy in accordance with the Renewable Energy Directive (EU) 2018/2001, including the sustainability criteria established therein;
- Development of intelligent energy systems, networks and storage outside TEN-E;
- Promoting adaptation to climate change and disaster risk prevention, resilience, taking into account ecosystem-based approaches;
- Promoting access to sustainable water management;
- Promoting the transition to a circular and resource-efficient economy;
- Improving the protection and conservation of nature, biodiversity and ecological infrastructure, including in urban areas, and reducing all forms of pollution;
- Promoting sustainable multimodal urban mobility as part of the transition to a carbon-free net economy.

Following a SWOT analysis, a series of opportunities were identified such as:

- Resilience and energy efficiency of public buildings: Police building, town hall building, etc.;
- Recharging points for electric vehicles with a fast charging capacity of at least 50 kW;
- Tracks for bicycles and light electric vehicles;
- Purchase of electric minibuses for community purposes;
- Rehabilitation of utility networks and public lighting at a sustained pace through the use of renewable energy;
- Thermal rehabilitation and introduction of alternative heating and energy saving systems at Mihoveni School, Șcheia commune, Suceava county;
- Modernization of the street lighting system (with LED lamps) in Șcheia commune, Suceava county.

The community of Șcheia will benefit from the construction of a cultural-sports complex with a total area of 2.247 m^2. The electricity supply will be made through a three-phase connection from the existing distribution network in the area.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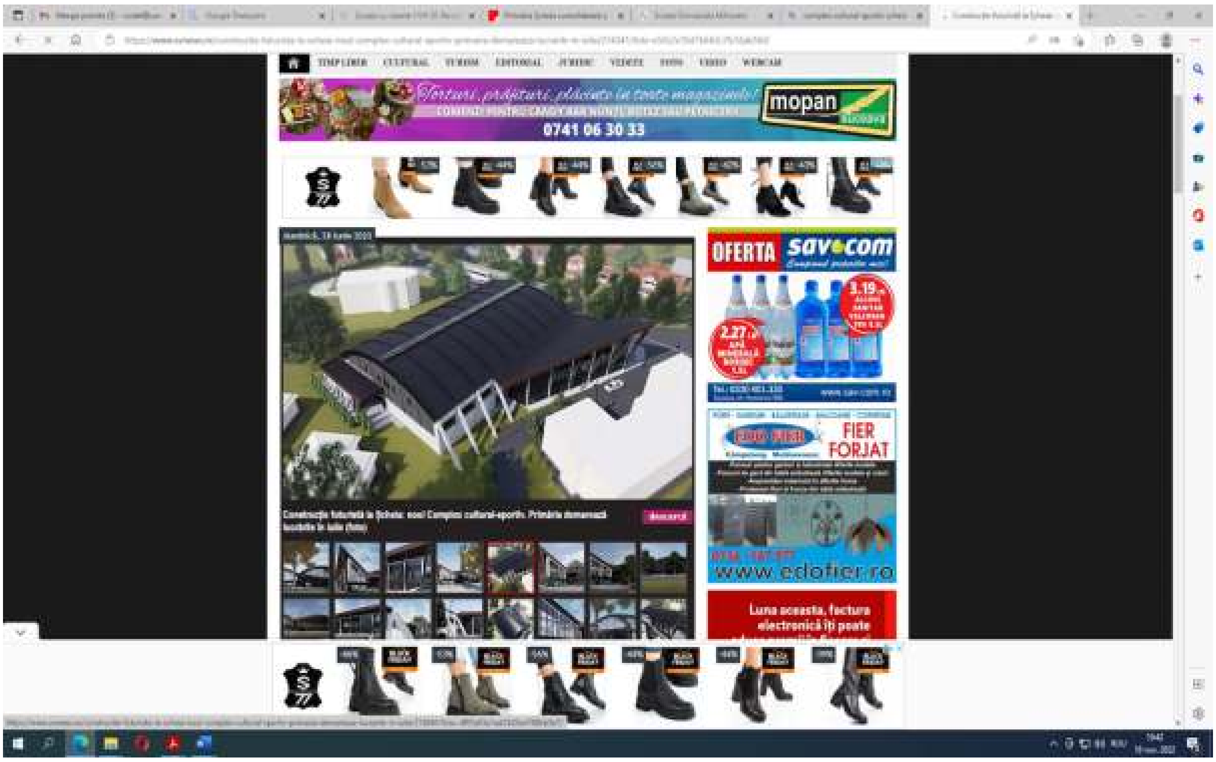
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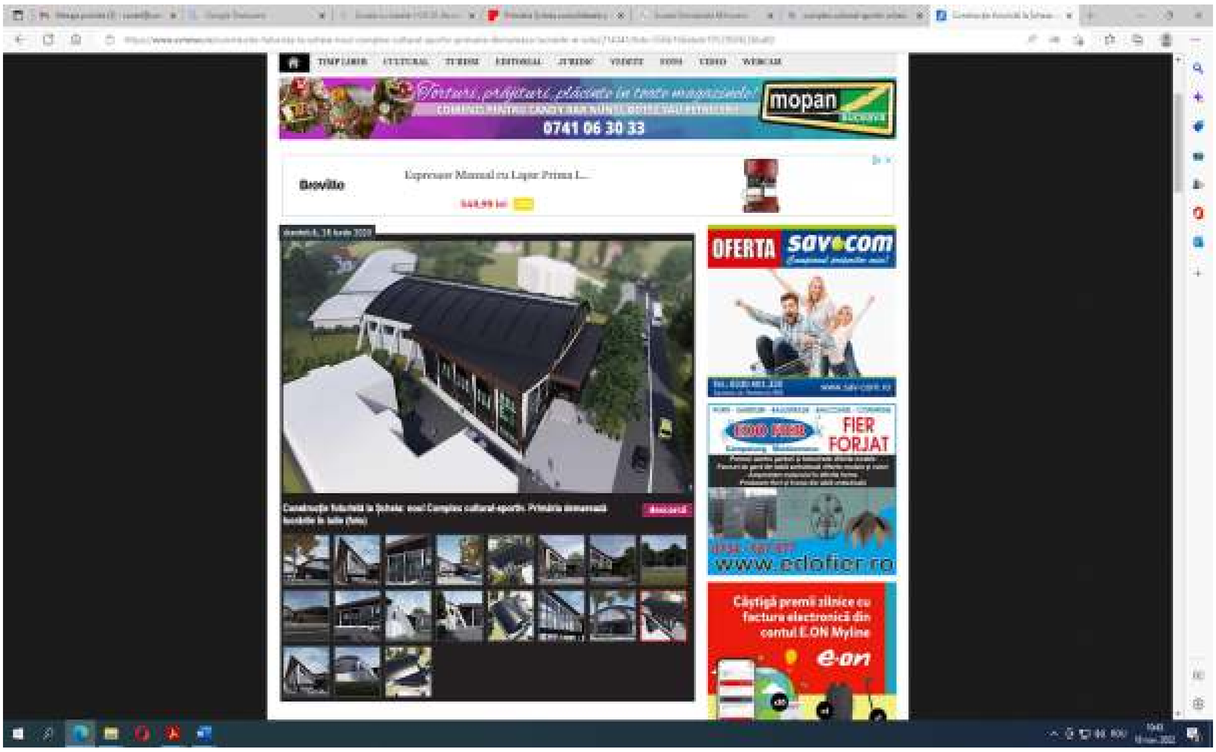
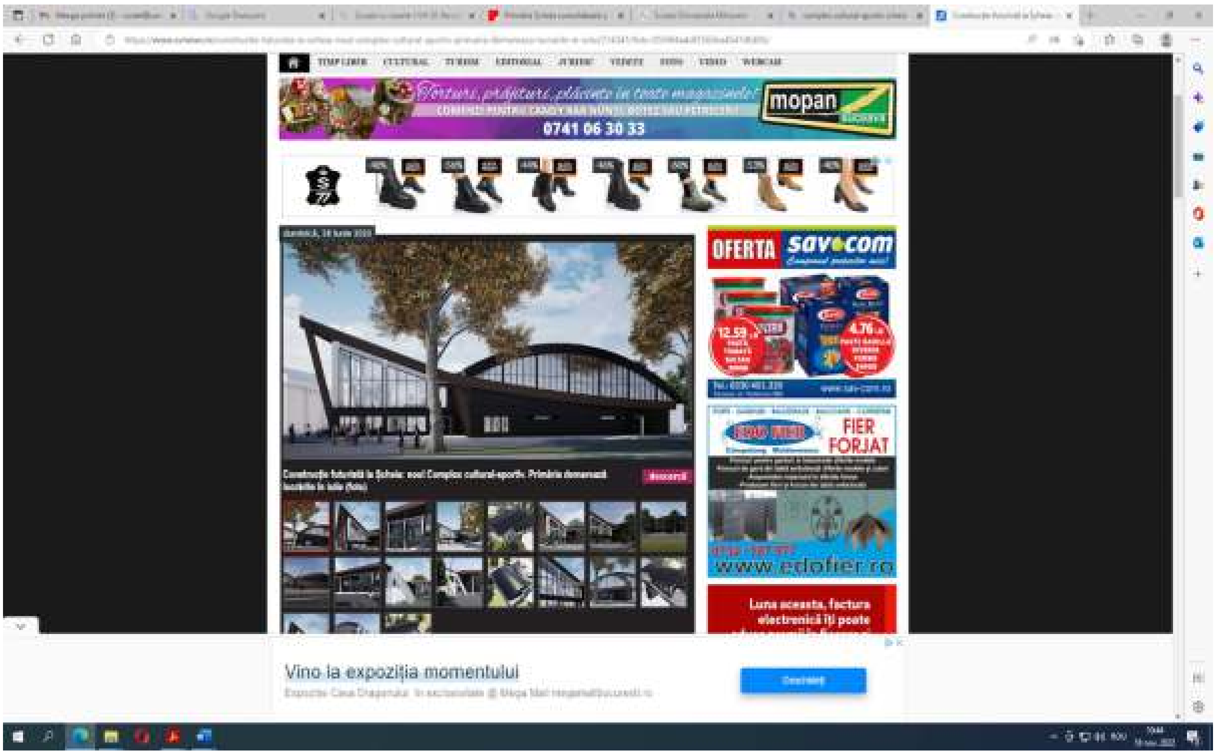




Cultural-sportscomplex, Șcheiacommune

Heating for the winter period and cooling in the summer period will be done with the help of heat pumps. The distribution of the heating agent will be done through distribution pipes positioned at the level of the floor and the fan coil units.

The preparation of hot water for consumption during the summer period will be provided by solar collectors. The water will be stored in a large capacity storage tank. To ensure a microclimate as pure as possible, the air will be treated. The use of air conditioning and ventilation equipment will help save energy by recovering the heat from the exhausted/treated air and reintroducing it inside according to the new European directives.

II. STUDIES CARRIED OUT WITHIN THE NESICA PROJECT

1. Carrying out the energy audit for the City Hall building

Based on the association agreement with "Stefan cel Mare" University in Suceava, within the "New Energy Solutions in Carpathian Area" - NESiCA project, the energy audit was carried out for a City Hall building in order to rehabilitate and modernize it. The building has two bodies and was built in two stages: the first body (town hall) in 1996 and the second (extension – garages and offices) in 2006. The building is oriented with the main facade (entrance) to the South-West.

The resistance structure of the building is made up as follows:

- continuous plain concrete foundation, with a reinforced concrete foundation beam;
- load-bearing walls of spatial structure made of cores and belts, with masonry filling from GVP (initial body) and BCA (extension);
- reinforced concrete floor over the ground floor and first floor;
- the roof is made of wooden frame and galvanized sheet covering.

City Hall Building, Șcheia commune

The exterior carpentry is PVC framed and double glazed. The free height of the rooms is 3.40 m on the ground floor and 3.20 m on the first floor. The basement of the building is intended for ALA shelter and civil defense headquarters.

The construction has the height regime of partial basement + ground floor + floor + tower for the first body and ground floor + floor for the extension. The surfaces developed by levels are presented in the following table:

	Initial body [m²]	Extension [m²]	Total [m²]
Basement	109,00	0,00	**109,00**
Ground floor	368,00	148,80	**516,80**
Floor	279,00	148,80	**427,80**
Tower	42,00	0,00	**42,00**
	798,00	297,60	**1095,60**

The building is connected to the following utilities:
- electricity supply;
- natural gas supply;
- drinking water and sewage networks;
- road and pedestrian access.

Heating and domestic hot water are provided by an own thermal power plant fueled by natural gas with two HERMANN boilers with a power of 2x84 kW. On the facade of the building there are 2 SPLIT type air conditioning equipment (12000 BTU/h) for the local air conditioning of the office spaces.

The energy rating of the building is made according to the specific consumption corresponding to the utilities in the building and the penalties established according to the operation. The classification in energy classes is done according to the specific energy consumption for each type of consumer according to the specific energy scale.

The main facade of the City Hall building, Şcheia

The rear facade of the City Hall building, Şcheia

The thermal energy distribution collector and the thermal plant

The energy notation of the reference building is carried out according to the specific consumption related to the utilities in the building, using the energy scales corresponding to each consumption, considering the penalties p0 = 1.

Electricity consumption for air conditioning (according to MC001 - PII Methodology):

Q_{clim} [kWh/year]	A_{inc} [m²]	q_{clim} [kWh/m²year]
15.839,76	832,20	19,03

Electricity consumption for lighting (according to Methodology Mc001 – PII):

W_{ilum} [kWh/year]	A_{inc} [m²]	W_{ilum} [kWh/m²year]
12.343,68	832,20	14,83

Calculation of primary energy consumed and CO^2 emissions:

Q_{fh} [kWh/ year]	Q_{acc} [kWh/ year]	Q_{clim} [kWh/ year]	W_{ilum} [kWh/ year]	E_p [kWh/ year]	E_{CO2} [kg CO_2 year]	A_{inc} [m²]	e_{CO_2} [kg CO_2/m² year]
70.234,63	28.393,78	15.839,76	12.343,68	189.235,86	28.645,67	832,20	34,42

Identification of modernization measures. Rehabilitated building

Solution package 1

- thermal insulation of the external walls with 10 cm of fireproof expanded polystyrene and on the contour of the carpentry gaps with 3 cm of fireproof extruded polystyrene;
- thermal insulation of the floor above the basement with 8 cm fireproof expanded polystyrene;
- thermal insulation of the plinth on the outer face with 10 cm of fireproof extruded polystyrene;
- thermal insulation of the floor towards the bridge with 20 cm of basalt wool.

RESULTS:

Energy consumption for air conditioning:

Q_{clim} [kWh/ year]	A_{inc} [m²]	q_{clim} [kWh/m² year]
9.008,26	832,20	10,82

Electricity consumption for lighting:

Wilum [kWh]	Ainc [m^2]	Wilum [kWh/m^2 year]
12.343,68	832,20	14,83

Calculation of primary energy consumed and CO_2 emissions:

Qfh [kWh/ year]	Qacc [kWh/ year]	Qclim [kWh/ year]	Wilum [kWh/ year]	Ep [kWh/ year]	ECO2 [kg Co_2 year]	Ainc [m^2]	eCO₂ [kg CO_2/m^2 year]
70.055,79	29.039,10	9.008,26	12.343,68	171.883,08	26.698,68	832,20	32,08

Solution package 2

-thermal insulation of the external walls with 10 cm of fireproof expanded polystyrene and on the contour of the carpentry gaps with 3 cm of fireproof extruded polystyrene;

- thermal insulation of the floor above the basement with 8 cm fireproof expanded polystyrene;
- thermal insulation of the plinth on the outer face with 10 cm of fireproof extruded polystyrene;
- thermal insulation of the floor towards the bridge with 20 cm basalt mineral wool;
- replacement of boilers in the thermal plant with high efficiency condensing boilers.

RESULTS:

Energy consumption for air conditioning:

Qclim [kWh/ year]	Ainc [m^2]	qclim [kWh/m^2 year]
9.008,26	832,20	10,82

Electricity consumption for lighting:

Wilum [kWh/ year]	Ainc [m^2]	Wilum [kWh/m^2 year]
12.343,68	832,20	14,83

Calculation of primary energy consumed and CO_2 emissions:

Qfh [kWh/ year]	Qacc [kWh/ year]	Qclim [kWh/ year]	Wilum [kWh/ year]	Ep [kWh/ year]	ECO2 [kg Co_2 year]	Ainc [m^2]	eCO₂ [kg CO_2/m^2 year]
59.560,45	27.185,54	9.008,26	12.343,68	15.7434,87	24.167,16	832,20	29,04

Solution package 3

- thermal insulation of the external walls with 10 cm of fireproof expanded polystyrene and on the contour of the carpentry gaps with 3 cm of fireproof extruded polystyrene;
- thermal insulation of the floor above the basement with 8 cm fireproof expanded polystyrene;
- thermal insulation of the plinth on the outer face with 10 cm of fireproof extruded polystyrene;
- thermal insulation of the floor towards the bridge with 20 cm basalt mineral wool;
- replacement of boilers in the thermal plant with high efficiency condensing boilers;
- installation of alternative thermal and electrical energy production systems;
- installation of a mechanical ventilation system with heat recovery to ensure indoor air quality and comfort conditions in the occupied spaces.

The results obtained in variant II (Solution Package 2) are used for the building envelope and installations.

The effect of installing thermal and electrical energy production systems on greenhouse gas emissions is analysed.

The effect of installing alternative thermal and electrical energy production systems on greenhouse gas emissions:

a) Alternative thermal energy production systems (heat pump):

- estimated annual thermal energy requirement for heating and hot water preparation after rehabilitation: 86.745,98 kWh/year;
- the average performance coefficient of the heat pump: COP=3;
- the minimum amount of thermal energy estimated to be produced annually with the help of the heat pump (30% of the estimated annual thermal energy requirement): 26.023,79 kWh/year;
- the minimum amount of cold for cooling estimated to be produced annually with the help of the heat pump (50% of the estimated annual energy requirement for air conditioning): 4.504,13 kWh/year;
- annual energy saving as a result of using the heat pump: 20.351,95 kWh/year.

b) Alternative electricity production systems (photovoltaic panels):

- estimated annual need for electricity after rehabilitation (lighting and heat pump operation): 22.519,65 kWh/year;
- the minimum amount of electricity estimated to be produced annually from local RES (10% of the estimated annual electricity demand): 2.251,97 kWh/year;
- annual electricity savings: 2.251,97 kWh/year.

Calculation of primary energy consumed and CO_2 emissions:

Q_{fh} [kWh/ year]	Q_{acc} [kWh/ year]	Q_{clim} [kWh/ year]	W_{ilum} [kWh/ year]	E_p [kWh/ year]	E_{CO2} [kg CO_2 year]	A_{inc} [m^2]	e_{CO_2} [kg CO_2/m^2 year]
59560,45	27185,54	9008,26	12343,68	140165,63	17116,47	832,20	20,57

Cumulative effects:

- estimated annual energy requirement of the building after rehabilitation: 108.097,92kWh/year
- total consumption covered by renewable energy sources: 20.91% (22.603,91 kWh/year)
- the annual reduction of CO_2-equivalent greenhouse gas emissions as a result of the use of local renewable energy sources: 7.050,69 [kgCO_2/year];
- total annual energy savings (compared to the non-rehabilitating building situation): 176.094,91 kWh/year;
- the total annual reduction of CO_2-equivalent greenhouse gas emissions: 39.188,97 [kgCO_2/year].

The installation of a mechanical ventilation system does not result in energy savings compared to the existing situation, but it is required to ensure indoor air quality and comfort conditions in the occupied spaces.

BUILDING ENERGY MODERNIZATION SOLUTIONS

A. CONSTRUCTIONS

1. THERMAL INSULATION OF EXTERNAL WALLS

Thermal insulation of the external walls with 10 cm fireproof expanded polystyrene. On the contour of the carpentry, the thermal insulation is made of extruded polystyrene plates with a thickness of 3 cm, in the area of the external jambs and the sills, providing adequate reinforcement and protection profiles (aluminum) as well as additional strips of glass fiber or fibers organic. When applying the thermos-system, special attention will be paid to covering the existing thermal bridges.

The edging will be done with continuous horizontal strips of basalt mineral wool, with the reaction to fire class A1 or A2-s1, d0, arranged in front of all the floors of the building with a minimum width of 0.30 m and with the same thickness as the polystyrene used for thermal insulation of the facade.

This is how the thermal resistance of the external walls is increased above the minimum value of 1.70 [m^2K/W] provided by the technical regulation Mc 001/1-2006 (supplemented by Order 2641/2017).

2. THERMAL INSULATION OF THE FLOOR ABOVE THE LAST LEVEL

Thermal insulation of the floor to the bridge with 20 cm basaltic mineral wool.

Thus, it is achieved, the increase of the thermal resistance of the upper floor over the minimum value of 5.00 [m^2K/W] provided by the technical regulation MC 001/1-2006 (completion by order 2641/2017).

3. Thermal insulation of the lower floor

Thermal insulation of the floor above the basement with fire-resistant expanded polystyrene in a thickness of 8 cm. Thermal insulation of the lower floor by mounting, on the outer face of the plinth, a heat-insulating layer characterized by a good behavior to the action of humidity (extruded polystyrene plates with a minimum thickness of 8 cm). The heat-insulating layer will be fixed both mechanically and by gluing and will be protected on the outside with a layer of reinforced plaster.

This is how the thermal resistance of the lower floor is increased above the minimum value of 2.60 [m^2K/W] provided by the technical regulation Mc 001/1-2006 (supplemented by Order 2641/2017).

B. FACILITIES

4. HEATING INSTALLATION

Replacement of boilers in the thermal plant with high efficiency condensing boilers.

5. INSTALLATION OF ALTERNATIVE THERMAL AND ELECTRICAL ENERGY PRODUCTION SYSTEMS

The installation of heat pumps to cover part of the building's heat requirement but also the cooling requirement for air conditioning.

Installation of photovoltaic solar panels. The energy source (installation/electricity production capacity) will be dimensioned to use the energy produced only to cover the annual energy requirement of the building (without the distribution of energy in the public network).

6. INSTALLATION OF A MECHANICAL VENTILATION SYSTEM

Installation of a mechanical ventilation system with heat recovery to ensure indoor air quality and comfort conditions in occupied spaces.

Economic analysis of building energy modernization solutions

During the energy audit, the options for improving the thermal performance of the tire and the installations presented above were analyzed.

Input data:

a) utility costs:
- thermal energy: 0.060 euro/kWh;
- electricity: 0.130 euro/kWh.

b) heat-insulating materials and installation equipment (estimated prices, without VAT - offers from construction and execution material companies):
- expanded polystyrene: 40 euros/m^2;
- extruded polystyrene: 95 euros/m^2;
- basalt wool: 90 euros/m^2;

- materials + workmanship without polystyrene exterior walls 30 euros/m^2;
- materials + labor without basalt wool thermal insulation upper floor 25 euros/m^2;
- materials + labor without polystyrene lower floor 4 euros/m^2.

The annual saving of thermal energy and electricity, respectively, as a result of the insulation of the building envelope and the modernization of the heating, domestic hot water and lighting installations:

Solution package 1

Et=(204042,25-70055,79)+(16163,89-9008,26)=141142,10 [kWh/year]

Solution package 2

Et=(204042,25-59560,45)+(16163,89-9008,26)+ (29039,10-27185,54)
Et=153491,00 [kWh/year]

Solution package 3

Et=153491,00 +21433,28=174924,28 [kWh/year]
Ee=2306,03 [kWh/year]

Conclusions. The implementation of the intervention works proposed by this energy audit has the effect of reducing maintenance costs for utilities, reducing the effects of climate change, by reducing greenhouse gas emissions as a result of reducing fuel consumption and improving the architectural appearance of Șcheia commune, Suceava county.

Solution Package 3 from the energy audit is recommended, which allows compliance with the minimum energy performance requirements provided for in technical regulation Mc 001/1-2006 (supplemented by Order 2641/2017).

Next, the most important data resulting from the energy audit are centralized:
- specific annual energy consumption for heating for the audited building: 245.18 kWh/m^2 year;
- the total annual specific consumption of primary energy for the audited building: 417.44 kWh/m^2 year;
- the specific annual index of CO_2 equivalent emissions: 67.66 kgCO_2/m^2 year;
- the energy performance of the audited building (energy rating): 83.61;
- global thermal insulation coefficient G1 for the audited building: 0.73 W/m^3K;
- global thermal insulation coefficient G1ref. of the reference building: 0.29 W/m^3K.

Solution Package 3:

- investment recovery period, under conditions of economic efficiency: 12.89 years;
- global thermal insulation coefficient G1 for the rehabilitated building: 0.26 W/m^3K;
- the annual specific energy consumption for heating corresponding to the rehabilitated building: 71.57 kWh/m^2 year;
- annual energy saving: 177.230,32 kWh/year; 15.24 t.e.p.; 65.86%;
- the building's annual specific primary energy consumption from non-renewable sources for heating the building: 52.47 kWh/m^2 year;
- the specific annual index of CO_2 equivalent emissions: 20.57 kgCO_2/m^2 year

- the estimated annual decrease in CO_2-equivalent greenhouse gas emissions: 39.19 tons CO_2/year (39188.97 $kgCO_2$/year);
- the specific investment, without VAT (construction - installations/useful area): 0.820 thousand lei/m^2 a.u.

Since the existing building does not meet the current requirements regarding the energy performance of buildings, it is recommended to rehabilitate the building thermally and fit the building into the minimum energy performance requirements provided in the technical regulation Mc 001/1-2006 (supplemented by Order 2641/2017):
- global thermal insulation coefficient G ≤ G1ref [W/m^3K];
- the specific annual consumption of primary energy from renewable sources for heating the building: qyear ≤ qyear,max (qyear,max = 60 [kWh/m^2 year], office building).

At the reception of the building after rehabilitation, the energy performance certificate of the building will be issued (according to Law 372/2005 on the energy performance of buildings) which will certify the new specific consumptions for heating, domestic hot water, air conditioning, ventilation and lighting.

2. Energy performance certificate for the City Hall building of Şcheia

The energy performance certificate for the Town Hall building of Șcheia, Suceava county, was made based on the calculation methodology of the Energy Performance of Buildings developed in application of Law 372/2005. The energy certification of the building is made according to the total energy consumption of the building, estimated by the thermal and energy analysis of the construction and related installations. The energy rating of the building takes into account the penalties due to the irrational use of energy.

Characteristics of the certified building:
- Useful area: 832.2 m^2;
- Building category: City Hall;
- Built-up area: 1.095,6 m^2;
- Height regime: Sp+P+E+Tower;
- Internal volume of the building: 2.746,26 m^3;
- Year of construction: 1996 (extension 2006).

The following data were taken into account:
1. Annual specific energy consumption: 314.33 kWh/m^2 year (Certified Building) / 152.38 kWh/m^2 year (Reference Building);
2. CO_2 equivalent emission index [$kgCO_2$/m^2 year]: 67.66 kWh/m^2 year (Certified Building) / 34.42 kWh/m^2 year (Reference Building).

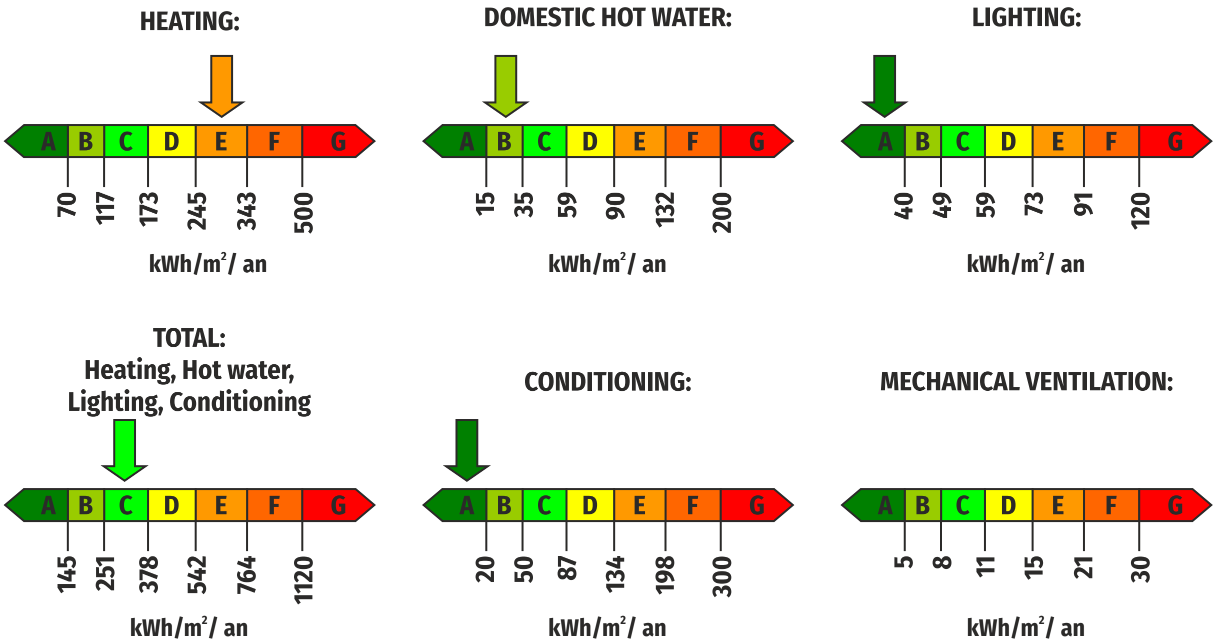
Annual specific energy consumption [kWh/m^2 year] for:		Energy class	
		Certified building	Reference building
Heating	248,18	E	B
Hot water	34,89	B	B
Conditioning	19,42	A	A

Mechanical ventilation	–	–	–
Artificial lighting	14,83	A	A

The energy performance of the reference building can be identified in the following table.

Annual specific energy consumption [kWh/m²year] for:		Energy rating
Heating:	84,40	14,83
Domestic hot water:	34,12	
Air conditioning:	19,03	
Mechanical ventilation:	–	
Lighting:	14,83	

The specific annual consumption of energy from renewable sources is considered equal to 0, the building not having implemented sources of thermal and electrical energy production. In the following, the data obtained regarding the assessment of the energy performance of the building, respectively the energy classification grids of the building according to the specific annual heat consumption, are presented.



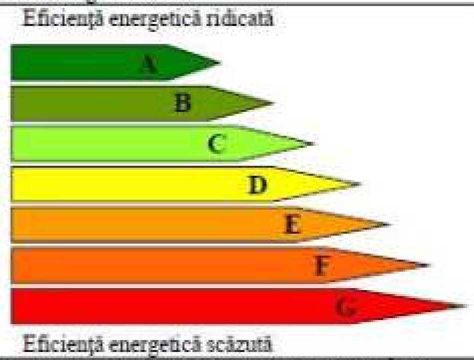
Energy classification grids of the building depending on the specific annual heat consumption

Anexa 1

Cod poştal localitate	Nr. înregistrare la Consiliul Local	Data înregistrării (z z l l a a)
7 2 7 5 2 5		

Certificat de performanţă energetică

Performanţa energetică a clădirii	Notare energetică	83,61
Sistemul de certificare: *Metodologia de calcul a Performanţei Energetice a Clădirilor elaborată în aplicarea Legii 372/2005*	Clădirea certificată	Clădirea de referinţă
Eficienţă energetică ridicată … Eficienţă energetică scăzută	C	B
Consum anual specific de energie [kWh/m²an]	314,33	152,38
Indice de emisii echivalent CO_2 [kg_{CO_2}/m^2an]	67,66	34,42



Consum anual specific de energie [kWh/m²an] pentru:		Clasă energetică – Clădirea certificată	Clasă energetică – Clădirea de referinţă
Încălzire	245,18	E	B
Apă caldă de consum	34,89	B	B
Climatizare	19,42	A	A
Ventilare mecanică	-	-	-
Iluminat artificial	14,83	A	A

Consum anual specific de energie din surse regenerabile [kWh/m²an]: 0

Date privind clădirea certificată:

Adresa clădirii: sat Şcheia, com. Şcheia, jud. Suceava

Categoria clădirii: Primărie — Aria utilă: 832,20 m²

Regim de înălţime: Sp+P+E+turn — Aria construită desfăşurată: 1095,60 m²

Anul construirii: 1996 (extindere 2006) — Volumul interior al clădirii: 2746,26 m³

Scopul elaborării certificatului energetic: **reabilitare şi modernizare**

Programul de calcul utilizat: calcul Excel – program propriu **versiunea:** 2019

Date privind identificarea auditorului energetic pentru clădiri:

Specialitatea (c, i, ci)	Numele şi prenumele	Seria şi nr. certificat de atestare	Nr. şi data înregistrării certificatului în registrul auditorului	Semnătura şi ştampila auditorului
I c, i	**Atănăsoae Pavel**	**BA 00776, BA 00844**	**1264/30.09.2020**	

Certificarea energetică a clădirii este făcută funcţie de consumul total de energie al clădirii, estimat prin analiza termică şi energetică a construcţiei şi instalaţiilor aferente.

Notarea energetică a clădirii ţine seama de penalizările datorate utilizării neraţionale a energiei.

Perioada de valabilitate a prezentului Certificat Energetic este de 10 ani de la data eliberării acestuia.

The energy performance certificate made for the Şcheia Town Hall building

Recommendations for reducing costs by improving the energy performance of the building:

A. Recommended solutions for the building envelope:

- Thermal insulation of external walls;
- Thermal insulation of the upper floor;
- Thermal insulation of the lower floor.

B. Recommended solutions for the installations related to the building:

- Replacement of boilers in the thermal plant with high efficiency condensing boilers;
- The use of renewable energy sources to ensure utilities in the building;
- Introduction of an organized mechanical ventilation system.

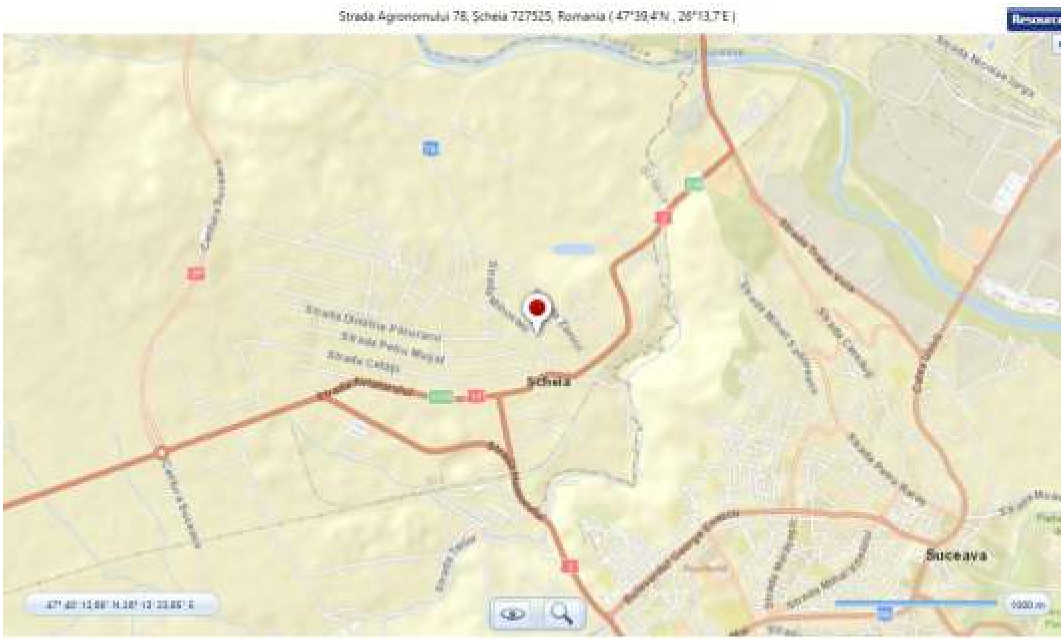
The energy certification of the building is made according to the total energy consumption of the building, estimated by the thermal and energy analysis of the construction and related installations. The energy rating of the building takes into account the penalties due to the irrational use of energy.

III. SOLUTIONS PROPOSED WITHIN THE NESICA PROJECT REGARDING INCREASING ENERGY EFFICIENCY

The region of the municipality of Şcheia is characterized by moderate values of solar irradiance, temperature and wind speed, as can be seen from the following representations. The average value of solar irradiance is 3.23 kWh/m^2/day, and that of the wind speed is 4.88 m/s, while the average daily temperature value in the region of Şcheia commune is 7.94 °C.

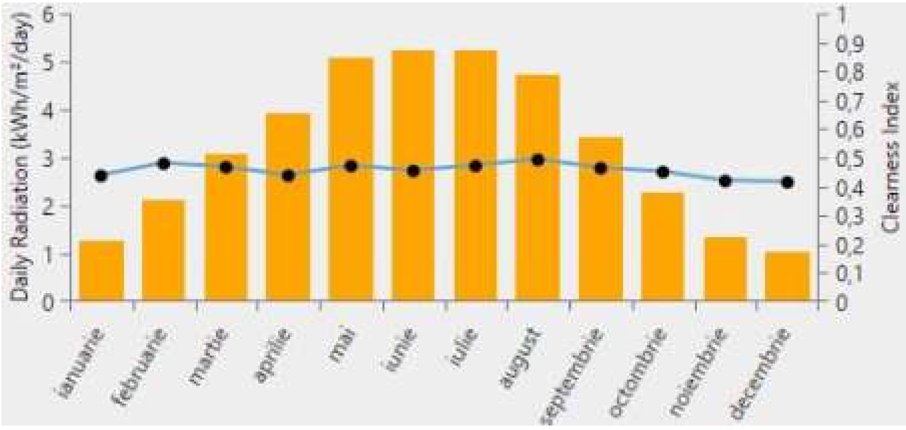
Implementation of a energy production system for the City Hall building, Scheia

In the following, a series of solutions are proposed for the supply of electricity from renewable sources for the City Hall building, in order to increase energy efficiency. The simplest measure to implement refers to photovoltaic sources that can be integrated into the structure of buildings or mounted and exploited using a neighboring land area. The disadvantage of the implementation of these photovoltaic sources boils down to the climatic conditions in the North-East area, which are inferior to those in the South of Romania, especially in the cold season. The use of photovoltaic panels as a source of electricity production in parallel with heat pumps for heating buildings is a recommendation.

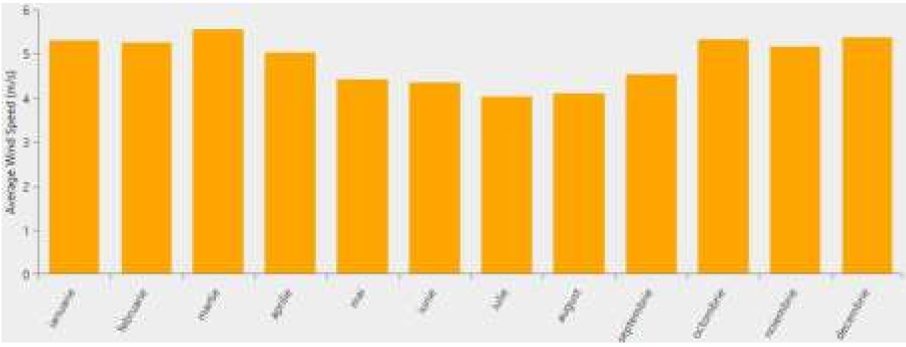


Şcheia commune, Suceava county. Geographical location

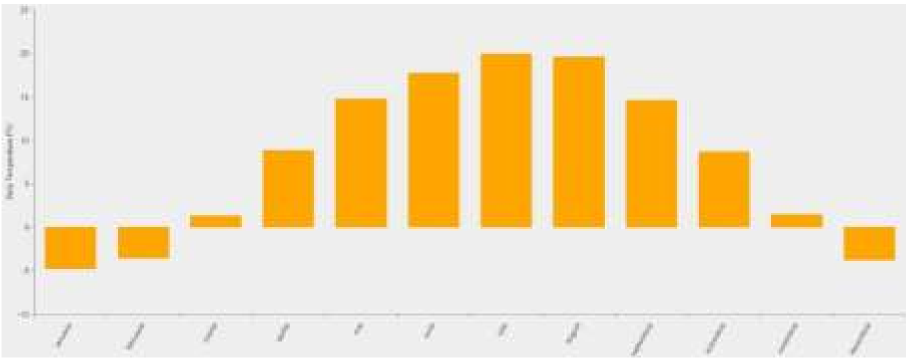
The present study was carried out based on the recommendations of the experts who prepared the energy audit. Thus, the electricity production system will be dimensioned in such a way as to cover the annual electricity requirement of the building identified by the energy audit carried out for the City Hall building.



Average monthly value of solar irradiance in the region of Şcheia commune



Average daily values of wind speed in the region of Şcheia commune

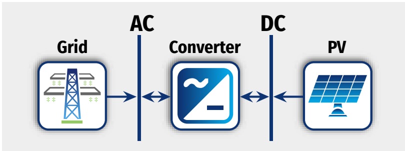


Average daily temperature values in the region of Şcheia commune

According to existing data, the electricity consumption of the Şcheia City Hall building is 22.51 MWh/year, consumption valid to cover the consumption of the lighting system and that of the heat pump of the rehabilitated building following the application of solution package no. 3.

To compensate for this amount of electricity, it is recommended to implement a photovoltaic system on the roof of the building with a total installed power of 24 kW. It was taken into account that the building is positioned in the South-West direction and the two slopes of the roof are at approximately 600.

The operating block diagram of the on-grid photovoltaic system includes a photovoltaic source with an installed power of 24 kW and an inverter for transferring the energy produced to the network, according to the operating block diagram.



Block diagram of the operation of the energy production system

For the analysis of the operation of the on-grid photovoltaic system, the following were established:

1. Photovoltaic panels are mounted on the roof of the building at a panel tilt angle of 600.
2. The following were taken into account: the effect of temperature (-0.50%/°C) on the power produced by the photovoltaic panels, the efficiency of the panels given by the manufacturer under standard test conditions (21%) and the standard operating temperature of the photovoltaic cell (47 °C).

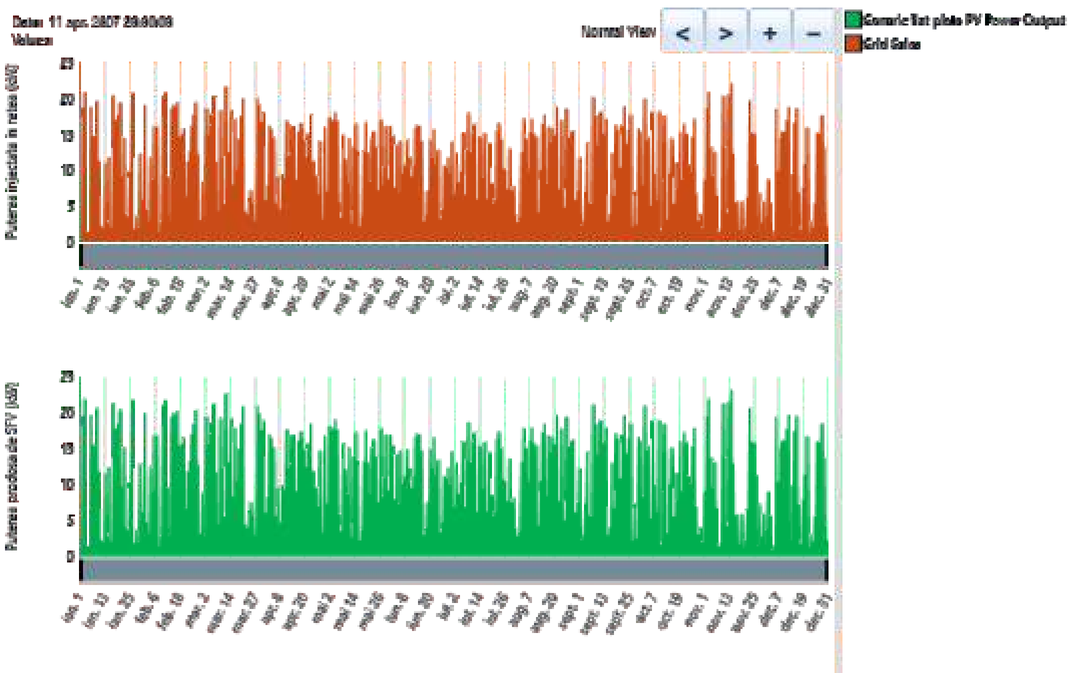
The results obtained from the modeling highlight a series of characteristics of the proposed system, centralized in the following table. It is found that the proposed system will produce, in the climatic conditions specific to the area, a quantity of electricity in the amount of 23.842 MWh/year.

Photovoltaic system characteristics		
The amount of energy produced annually	**23842**	**kWh/year**
Average energy produced in a day	65,3	kWh/day
Maximum power produced	11,6	kW
Capacity factor	11,3	%
Hours of operation	4374	hours/year

Electric energy injected into the power grid		
January	1394	kWh
February	1689	kWh
March	2045	kWh
April	2082	kWh
May	2448	kWh
June	2268	kWh

July	2344	kWh
August	2390	kWh
September	1991	kWh
October	1607	kWh
November	1236	kWh
December	1157	kWh
TOTAL	**22650**	**kWh**

The following figure illustrates the variation of the power injected into the electrical network by the photovoltaic system as well as the power generated by the photovoltaic system in relation to the distribution of the global component of solar irradiance.



The electric power injected into the grid and the power produced by the photovoltaic system

Conclusions. By implementing a hybrid electricity production system with a total installed power of 24 kW, the building can cover its electricity consumption of 22.51 MWh/year. Installing a wind turbine is optional as it does not provide significant power input due to poor wind conditions.

IV. RESOURCES FOR THE IMPLEMENTATION OF THE BEST ENERGY EFFICIENCY SOLUTIONS IN THE MUNICIPALITY OF ŞCHEIA

Supporting development projects in the period 2021-2027 in the field of education, infrastructure, transport, spatial planning, environment, economy, tourism, culture, sport, leisure, health, social assistance, public administration, will lead to the economic growth of Şcheia municipality and increasing the standard of living of the area's inhabitants.

In order to achieve the proposed objectives, the aim is to attract community and private funds in a higher percentage and to reduce the funds from the state budget. Funding needs represent a quantification of local needs, regardless of the funding source (state budget, local budget, community funds, private funds).

The general concept "European funds" designates the non-refundable financing instruments allocated to the Member States of the European Union (EU), in order to reduce the economic and social development gaps between them. European funds are jointly managed by the European Commission and each individual member state. For Romania, the European Structural and Investment Funds (ESI Funds) are the main source of funding for the Operational Programs whose main objective is the implementation of the Economic and Social Cohesion Policy at the national level.

ESI funds include:
- The European Regional Development Fund (ERDF) supports investments aimed at: regional development (especially through investments in infrastructure), digital agenda, increasing the competitiveness of SMEs, energy efficiency and renewable energy, research and innovation, sustainable urban development. ERDF also supports cross-border, transnational and interregional cooperation within the objective of European territorial cooperation.

- The Cohesion Fund (CF) finances environmental, energy and transport infrastructure projects, by increasing energy efficiency, using renewable energy sources, developing rail transport, supporting intermodality, strengthening public transport, etc.

The measures proposed in the strategy of the municipality of Şcheia are consistent with the Operational Programs for the period 2021-2027. However, the absorption of available funds depends, along with the eligibility of actions, on the institutional capacity to initiate projects and work in partnership to achieve strategic goals. The 2021-2027 development strategy of the Șcheia commune is a legal working document of the Șcheia Local Council. The document has a normative and prospective character and commits to a permanent re-evaluation and optimization of the development options of the commune in order to adapt them to the evolution of economic and social realities. The purpose of the measures proposed in the strategy is to improve, among other things, the quality of the environment through awareness-raising activities regarding the importance of a clean environment in maintaining health, improving air quality, as well as efficient waste management and collection.

The priority interventions in the short, medium and long term are:

1. Non-polluting technologies, according to European standards;
2. LED lamps in the public street lighting network;
3. Implementation of systems for monitoring the quality of environmental factors (air, water, soil);
4. Integrated household waste management, industrial waste management;
5. Thermal rehabilitation of the buildings under the administration of the City Hall;
6. Rehabilitation of utility networks and public lighting at a sustained pace through the use of renewable energy;
7. Establishment of recharging points for electric vehicles with a capacity of at least 50 kW.

Thermal rehabilitation and the introduction of alternative heating and energy-saving systems are also being considered, Mihoveni school, Şcheia commune, Suceava county, financed by the “Program on increasing energy efficiency and intelligent energy management in public buildings intended for units of education” - AFM.

The objective of the energy component is to address the main challenges of the energy sector in terms of decarbonisation and air pollution, respectively ensuring the green transition and digitization of the energy sector by promoting the production of electricity from renewable sources, energy efficiency and future technologies.

The proposed investments in the following years consider:

1. New electricity production capacities from renewable sources;
2. Renewable gas distribution infrastructure (using natural gas in combination with green hydrogen as a transitional measure), as well as green hydrogen production capacities and/or its use for electricity storage
3. Development of flexible and high-efficiency gas production capacities for cogeneration of electricity and heat (CHP) in the district heating sector, with a view to achieving deep decarbonisation;
4. Industrial chain of production and/or assembly and/or recycling of batteries, cells and photovoltaic panels (including auxiliary equipment), as well as new electrical energy storage capacities;
5. Ensuring energy efficiency in the industrial sector.

The **Energy component** responds to the flagship initiative Acceleration (Power-up) from the 2021 Annual Strategy on sustainable growth, which aims to give priority to perennial clean technologies, the development and use of renewable energy sources. Through reforms and investments that contribute to the replacement of coal in the energy mix and to the stimulation of electricity production from renewable sources, including green hydrogen, the Energy component of the PNRR contributes to accelerating the development and use of renewable energy sources, including green hydrogen, as well as to storage and integration of renewable energy into the energy system. The requested budget within the PNRR is 1.620,00 million euros.

The implementation of an energy efficiency program in schools is being considered. The budget of this program is over 500.000,00 Euros for UATs with a population of over 5.001,00 inhabitants, financed by the Environment Fund Administration.

Purpose: Increasing the energy efficiency of public buildings intended for educational institutions and improving the quality of the environment by reducing greenhouse gas emissions by reducing the annual final energy consumption.

Objectives: Modernization of public buildings intended for educational institutions, by financing activities/actions specific to the realization of investments to increase their energy performance, respectively:

- improving the thermal insulation of the building envelope (external walls, windows and doors, floor above the last level, floor above the basement), the cladding and coverings; as well as other envelope elements that enclose the air-conditioned space of the building;

- the introduction, rehabilitation and modernization, as appropriate, of the installations for the preparation, distribution and use of the thermal agent for heating and hot water for consumption, of ventilation and air conditioning systems, of mechanical ventilation systems with heat recovery, including passive cooling systems, as well as the purchase and installation of related equipment and connection to central heating systems, as appropriate;

- the use of renewable energy sources;

- implementing energy management systems aimed at improving energy efficiency and monitoring energy consumption (for example, purchasing, installing, maintaining and operating intelligent systems for managing and monitoring any type of energy to ensure indoor comfort conditions);

- replacing fluorescent and incandescent lighting fixtures with lighting fixtures with high energy efficiency and long lifespan, LED technology, in compliance with technical norms and regulations;

- optimization of indoor air quality through mechanical ventilation with individual or centralized units, as the case may be, with thermal energy recovery to ensure the necessary fresh air and humidity level, which ensures the health of users in the spaces where they work.

6. BEST ENERGY SOLUTIONS – CONCEPTS FOR PILOT COMMUNITIES IN SLOVAKIA

6.1 Zborov community

1. IDENTIFICATION DATA

Identification data of the client, the operator and the subject of the energy audit.

Identification of the customer and EA guarantor	
Company name/Name of natural person:	Municipality Zborov (for the United School Zborov)
Seat:	Zborov, Lesná 10, 086 33 Zborov
Registration number:	00322741
TIN:	2020624804
Name of statutory representative:	Mgr. Ján Šurkala, PhD.
Authorized representative:	PaedDr. Gabriela Hurajová (principal)
Contact person:	Mgr. Ján Šurkala, PhD.
Telephone:	+421948 212 206
E-mail:	jan.surkala@gmai.com, info@zborov.sk
EA subject:	Implementation of the measures to reduce energy consumption
Address:	Školská 478/14, 086 33 Zborov
Property legal relationship to the client and to the EA guarantor	The village of Zborov is the founder of the school and also the owner of the building

The energy auditor

The identification of the energy auditor	
Company name/Name of natural person:	Klima-Teplo designing, s.r.o
Seat:	Tolstého 3, 04001 Košice
Registration number:	44294476
TIN:	SK2022674731
Name of statutory representative:	Ing. Štefan Petkanič
Contact person:	Ing. Štefan Petkanič

Telephone:	+421 905 139 015
E-mail:	petkanic@klimateplo.sk
Identification data of the energy auditor:	VRANAY František Ing., PhD.
Address:	Kavečianska cesta 21, 04001 Košice
Certificate:	Number: 321/2014-0069
Phone	+421 905 505017
E-mail:	frantisek.vranay@tuke.sk
Administrator:	
Energy auditor	Assoc. Prof. Ing. František Vranay, PhD.
Co-administrator	Ing. Mikuláš Vranay

1. SUBJECT OF THE ENERGY AUDIT

Purpose of energy audit

The energy audit is processed in order to determine the potential of energy savings by implementing a significant renovation of the building and energy management.

The subject of the EA is:

- the assessment of thermal and technical properties of building structures,
- the energy consumption assessment of current technical systems of the building,
- proposed measures for the significant or in-depth renovation of the building,
- proposed measures for the reconstruction and modernization of technical systems in the building,
- determination of energy saving potential,
- economic and environmental assessment of proposed measures.

The energy audit is intended for the owner of the building:

- for the needs of the owner´s decision on the possibilities of implementing the proposed measures
- for the possibilities of implementing recommendations for improving the energy efficiency of the building
- as a basis for the preparation of project documentation for the building renovation.

Identification of the subject of the energy audit

Building, area: United School Zborov
Address: Školská 478, 086 33, Zborov
Parcel Number: **Cadastral Office Zborov 334/8**

Figure - Location of the energy audit object

2. ANALYSIS OF THE CURRENT STATE

The object of the assessed school is located on the premises of the municipality of Zborov in the district of Bardejov. In addition, the municipality of Zborov is the owner of the objects. Access to the area is by local communication.

The building is a school facility used only during the limited hours on working days. The building is not occupied during weekends, public holidays, and holidays. In the building, it is necessary to ensure operation in the winter months by heating as well as a suitable indoor environment (air quality) according to the purpose of the rooms and occupancy throughout the year. In addition to the quality of the environment, the supply of hot water and lighting on the premises is necessary. All these parameters should meet the prescribed requirements.

However, it must always be ensured that pupils and teachers feel comfortable in the building. The sense of comfort shall be subsequently reflected in productivity. The technology of the building environment complements the creation of this comfortable environment. The building consisting of interconnected objects in which energy is used for heating, hot water heating, and lighting is assessed as a whole.

The main building: Classrooms, offices, corridors, an apartment, a dining room, and a kitchen.
The building has a partial basement with two above-ground floors. There are gymnasiums and workshops in the building extension. The building envelope is made of 250 mm thick gas-silicate panels with 80 mm thick EPS insulation. The roof structure is a double roof made of reinforced concrete panels with thermal insulation. The roof is made of asphalt shingles with ventilated loft. The infill walls for the windows and doors are plastic with insulated double-glazed glass throughout the building. Floor structures are original with concrete underlayment, including hydro-insulation, Fibrex 10 mm insulation, and a floor covering according to the purpose of the rooms.

Gyms and workshops:
The building was built additionally as an extension. It is without a basement with one above-ground floor. The building envelope is made of Porfix fittings with a thickness of 250 mm and an insulation thickness of EPS 100 mm. The roof structure of the workshops is a double roof made of reinforced concrete panels with thermal insulation. The roof structure of the gyms is made of supporting trapezoidal sheets with perlite insulation of 60 mm, Heraclitus of 30 mm and Polsid boards of 50 mm thickness. The roof is made of asphalt shingles with a ventilated loft. The infill walls for the windows and doors are plastic with insulated double-glazed glass throughout the building. Floor structures with concrete underlayment, including hydro-insulation, EPS 100 mm insulation, and a floor covering according to the purpose of the rooms.

Heating: It is a hot-water heating system distributing heat through plate radiators. The radiators are already equipped with control valves with thermostatic heads. The heating system is hydraulically regulated. Distribution from the boiler room is led through the heated zones of the building (corridors under the ceiling, and in rooms above the floor). These pipelines are without thermal insulation. Moreover, pipelines contribute to the heating of the premises through which they pass. The heating source of is a mutual gas boiler room located in the extension of the building.

Hot water preparation: The preparation of the thermal heating for the building is provided in a gas boiler room with a 300-litre storage tank with circulation. Part of the distribution points is realized through an electric accumulation tank EOV 82 liters with distributions without circulation.

The washbasins far from the boiler room are equipped with electric flow heaters placed directly next to the furniture. The distribution points are washbasins, sinks, kitchen equipped with cooking and serving (sinks and washbasins), and hygienic facilities at gyms (washbasins and showers). Pipelines are led in space-limited conduits under the floor of the building, or in the walls. The pipes are thermally insulated. The quality of the insulation cannot be determined due to the inaccessible parts of the pipelines.

The state of the hot water preparation system corresponds to the period of operation, it is unsatisfactory (in terms of thermal insulation).

Lighting: Currently, the lighting system is mainly provided by fluorescent lamps with switches at the entrance to a room. This lighting system is unsatisfactory in terms of the following: electrical safety - building wiring does not meet current valid standards, outdated lighting, lighting intensity, lighting technical requirements for lighting according to the currently valid lighting standards.

Some of the lamps are already LED lamps with a total area of approx. 20%.

Electrical installation - electrical switchboards, fuses andswitchgear, sockets, and switches are in their original state, they are technically obsolete. Also, the socket and light wiring are led by aluminum wires.

Boiler room: It is part of the extension, where there are workshops and a gym with equipment. The technology of the boiler room for heating the entire set of objects is provided by natural gas boilers. The heat is supplied in the form of hot water with parameters of 60/45 °C by steel pipes. The pipes are led through the interior of heated rooms, suspended under the ceiling without thermal insulation, or above the floor alongthe wall of heated rooms. The heat source is provided by fourpieces of BUDERUS Logamax plus GB162-100 V2 natural gas boilers with a heat output of 95 kW each. The heated objects are divided into separate zones with their own pump includingequithermal regulation. Regulation, pumps, wiring, and insulation are all after reconstruction.

3. BASIC DATA ON ENERGY INPUTS AND OUTPUTS

In the subject of an energy audit, only energy inputs and energy consumption occur, energy outputs are not realized. The Municipal Office of Zborov is the owner of the entire building. The volumes of purchased energy carriers for the monitored years were as follows:

Electricity consumption:

Electrical energy consumers are normal operation, indoor and outdoor lighting systems, hot water heating, small electrical appliances of various types and inputs (PCs, copy machines, refrigerators and others).

Table - Summary data on electricity consumption

Electricity	Year			3-year average
	2018	2019	2020	
Consumption kWh/year:	72,399	82,128	70,473	**75,000**
Costs €/year: without VAT	11,439	12,556	11,374	**11,790**
Average price €/kWh	0.1580	0.1529	0.1614	**0.1572**

In the monitored years, the average electricity consumption reached 75,000 MWh/year what represents annual electricity costs of €11,790 at an average price of €0.1572/kWh without VAT.

Gas consumption for heating

Heat is produced by gas boilers in the building. An overview of natural gas consumption for heating, hot water heating (heating of hot water) and cooking, including partial costs, is shown in the following table:

Table - Summary data on gas consumption

GAS	Year			3-year average
	2018	2019	2020	
Consumption kWh/year:	642,850	734,910	550,220	**642,660**
Costs €/year: without VAT	23,808	36,260	27,440	**29,169**
Average price €/kWh	0.0370	0.0493	0.0499	**0.0454**

The average price for the monitored years is calculated at €0.0454/kWh without VAT.

Fuel consumption
Fuel is not part of the energy audit.

4. THERMAL TECHNICAL ASSESSMENT OF ENVELOPE STRUCTURES, ENERGY ASSESSMENT

Local and standardized climatic conditions

The methodology based on heating day degrees was used to calculate the heat demand to cover heat loss due to heat transfer and ventilation. In the following, the data for the monitored years are presented.

The heating mode of the building in real operation does not correspond to the number of day degrees in terms of the location. The heating in the building is adjusted to the building operation time, the rooms are always heated according to the need and occupancy of a room. The heating temperature of the interior spaces corresponds to the use of the building.

Standardized input data on external climatic conditions and the internal environment of the building were used to calculate the heat demand for heating purposes by the standardized assessment. The standardized assessment was used only for comparing the measured heat demand of the object according to STN 73 0540-2.

Table - Climatic conditions of the location

			NH	UH
Exterior calculated temperature	qe	(°C)	-13	-15
Wind zone, wind speed	v	(м/c)	–	do 2
Interior calculated temperature	qi	(°C)	20	19.5
φ Exterior temperature of the heating period	qae	(°C)	3.86	4.80
φ Number of heating days	d		212	232
φ Number of day degrees	D		3,422	3,768

NH - Standardized assessment
UH - Modified assessment

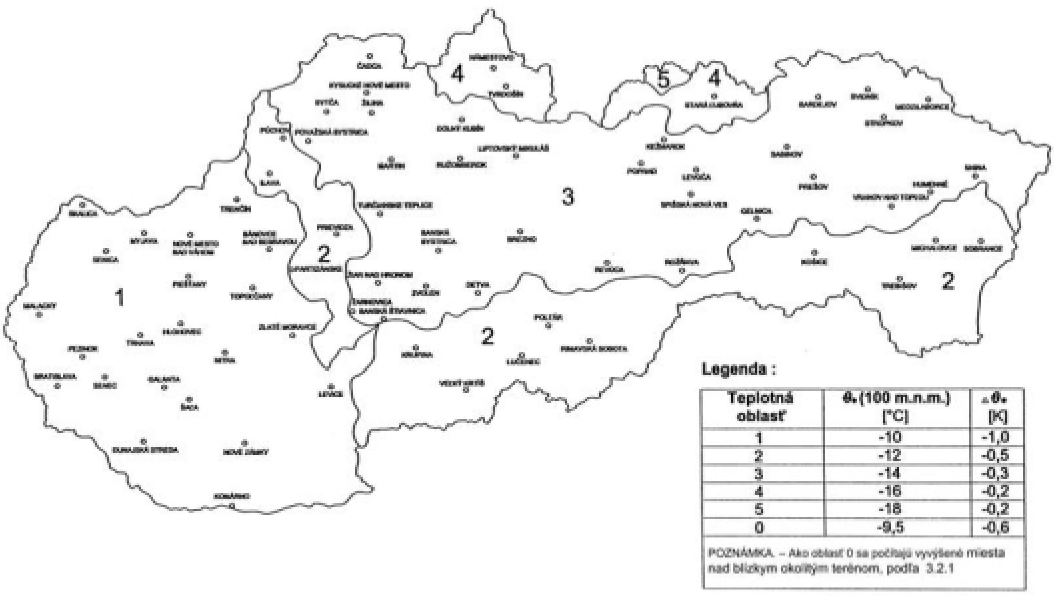


Figure Division of the Slovak Republic into temperature zones

In the thermal technical assessment, the following conditions were taken into account, according to STN 73 0540 - 3, location of Zborov, Bardejov district.

In the thermal technical calculations, the basic parameters of the building listed in the following table were used.

Table - Technical and geometric parameters of the building

CURRENT STATE			**Average temperature of CH (°C)**
School building and school premises - restoration			18.50
Total built-up area	A	(м²)	4,174.95
Perimeter of the built-up area	p	(м)	–
Building heated volume	Vb	(м³)	24,068.80
Surface area	Ab	(м²)	6,779.94
Cooled envelope	ΣAi	(м²)	12,110.86
Building form factor	ΣAi/Vb	(1/м)	0.50
Number of floors above ground			2.00
Average floor height	hk_{pr}	(м)	3.55

For the thermal technical assessment of the building, the project documentation mentioned at the beginning of the report was used. The necessary details were added during the inspection of the objects and after the consultations with the investor. The following is a detailed calculation of the thermal technical assessment of the current state of the building with a description of building structures, openings, etc. The partial calculations indicate whether the item complies with the currently valid regulations and criteria for the energy efficiency of buildings.

Thermal technical assessment of the building – current state

The sum of the areas of all solid building structures is 10,836.6 m². The heat transfer coefficient of the building structures is shown in the following table. The specific heat loss due to heat transfer within all solid building structures is 4,679.3 W/K, which represents 68.6% of the total specific heat loss due to heat transfer.

The sum of the areas of all types of openings is 1,274.2 m². The heat transfer coefficient of the openings is shown in the following table. The specific heat loss due to heat transfer within all openings is 1,537.3 W.K-1, which represents 22.5% of the total specific heat loss due to heat transfer. There were all the plastic windows and doors replaced are installed in the perimeter masonry walls.

The total area of the envelope structure is 12,110.86 m². The heat transfer coefficient of the envelope structure, including the specific heat loss due to thermal bridges, is 6,216.59 W.K-1. The specific heat loss due to thermal bridges is 605.54 W.K-1. According to STN 73 0540-2, meeting of the minimum requirement for the average heat transfer coefficient of the total envelope structures of the building is shown in the table.

The share of the individual structural elements and thermal bridges in the total specific heat loss in the heat transfer is shown in the following table.

COMPOSITION OF STRUCTURAL ELEMENTS ON THE SPECIFIC HEAT LOSS – CURRENT STATE

ITEM		AREA (m^2)	HT (W/K)	SHARE (%)
OS	Perimeter wall	2,486.7	711.5	10.4%
SCH	Roofing	4,175.0	2,309.2	33.8%
PDL	Flooring	4,175.0	1,658.6	24.3%
OTV	Openings	1,274.2	1,537.3	22.5%
TM	Thermal bridges	–	605.5	8.9%
SUM	**Envelope**	**12,110.9**	**6,822.1**	**100.0%**
SUM	**Solid structures**	**10,836.6**	**5,284.8**	**77.5%**

The heat demand for heating

The calculation of the heat demand for heating was made on the basis of the calculation of the heat loss due to heat transfer within structural elements and due to ventilation, which was reduced by heat gains. The total annual heat demand to cover heat loss due to transfer and ventilation is 473,716.73 kWh.

Assessment of the building in terms of the heat demand for heating

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operating time of heating was taken into account with the determined effect on a decrease of the internal temperature in the category of buildings – an administrative building.

Table - Assssment of the building according to STN 73 0540-2 – current state

Building form factor	(1/m)	ΣAi/Vb	**0.503**
Heat demand in CH in the reference heating season	(kWh)	Qh	**473,719.73**
Relative heat demand for heating	(kWh/m^2)	QEP	**69.87**
Standard value	(kWh/m^2)	QNEP	**53.20**
Recommended value	(kWh/m^2)	Qr1,EP	**27.60**
Target recommended value	(kWh/m^2)	Qr2,EP	**13.80**
Assessment of the building according to STN 73 0540 - 2		QEP ≤ $_{QN,EP}$	**Unsatisfactory**

The assessed building does not meet the energy criterion.

Classification of the building in terms of energy consumption - current state

The current state of the building does not meet the energy criterion. In terms of heating system, hot water preparation and lighting system, the total energy requirement falls into Class **C**. In terms of primary energy consumption, the building falls into Class **B**.

TOTAL ENERGY - C
PRIMARY ENERGY - B

Table - Classification of the building according to the place of energy consumption - current state

Classification of the building according to the place of energy consumption								School buiding and its premises	
	A	**B**	**C**	**D**	**E**	**F**	**G**	**current state**	
HEATING	25	56	84	112	140	138	OVER	**77.67**	**C**
HOT WATER	6	12	18	24	30	36	OVER	**11.77**	**B**
VENTILATION AND COOLING	0	0	0	0	0	0	OVER	**–**	**–**
LIGHTING	9	18	27	36	45	54	OVER	**4.28**	**A**
TOTAL	43	86	129	172	215	258	OVER	**93.73**	**C**
	A0	**A1**	**B**	**C**	**D**	**E**	**F**		
PRIMARY	34	68	136	204	272	340	OVER	**120.60**	**B**

5. PROPOSAL FOR MEASURES TO REDUCE ENERGY CONSUMPTION - BUILDING MODIFICATIONS

The following measures were proposed to reduce the energy demand of the building, which is the subject of the energy audit. The results of energy and economic calculations, as well as, the operational parameters of the building, its method and time of use were taken into account to design the measures. For the assessment of energy consumption reduction, the percentage rate of reduction in the energy demand of the building, determined by calculations based on the real energy consumption of the used technology, is taken into account. The monetary value of energy savings with an annual update rate of 2.5% shall be used in the calculation of the rate of return. All measures are energetically and economically assessed based on the average values of the energy and economic demands of building operation time for the years 2018-2020. The real discount rate, taking into account the annual inflation rate, was set at 3.0%. The amount of the investment costs was determined on the basis of the price lists and on the basis of the usual prices for proposed equipment and work. **Thermal insulation was designed to meet the required values of heat transfer coefficients, while technical feasibility was also taken into account.**

Захід 1: MODIFICATION OF BUILDING STRUCTURES

THE PROPOSED MEASURES

- **insulating of the perimeter wall, NOT RECOMMENDED**
- **insulating of the roof structure with 400 mm thick insulation, RECOMMENDED**
- **insulating of the flooring RECOMMENDED**
- **replacing of the openings with U=1.2 [W/m^2.K] RECOMMENDED**

USTIFICATION OF RECOMMENDED MEASURES

- THERE IS A HIGH QUALITY OF THE STRUCTURAL ELEMENTS, EVEN THOUGH STANDARD RECOMMENDED PARAMETERS ARE NO LONGER MET for objects built after 2015: Required – U-wall=0.22, U-Roof=0.10, U-Openings=1.0

- THE HIGH RATE OF RETURN MAKES THE MODIFICATIONS INEFFICIENT

The properties of the structural elements marked red in the following table are taken into consideration to calculate the assessment of the benefits of the proposed measures. It is assumed that the roof shall be insulated with 400 mm thick insulation.

Table - List of structural elements - proposed state

COMPOSITION OF STRUCTURAL ELEMENTS ON THE SPECIFIC HEAT LOSS – proposed state

ITEM		AREA (m^2)	HT (W/K)	SHARE (%)
OS	**Perimeter wall**	2,486.7	711.5	14.6%
SCH	**Roofing**	4,175.0	**348.6**	7.2%
PDL	**Flooring**	4,175.0	1,658.6	34.1%
OTV	**Openings**	1,274.2	1,537.3	31.6%
TM	**Thermal bridges**	-	605.5	12.5%
SUM	**Envelope**	12,110.9	4,861.6	100,0%
SUM	**Solid structures**	10,836.6	3,324.3	68.4%

Energy and economic assessment of the proposed Measure 1

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operation time of heating was taken into account with the determined effect on a decrease of the internal temperature during intermittent operation in the relevant category of buildings. In order to demonstrate achieving the energy efficiency of the building, the specific heat demand for heating should be lower than the standardized value. The results of the assessment are shown in the table.

Table - Assessment of the building according to STN 73 0540-2 – proposed state

Building form factor	(1/m)	$\Sigma A_i/V_b$	**0.503**
Heat demand in CH in the reference heating season	(kWh)	Q_h	**332,246.81**
Relative heat demand for heating	(kWh/m^2)	Q_{EP}	**49.00**
Standard value	(kWh/m^2)	Q_{NEP}	**53.20**
Recommended value	(kWh/m^2)	$Qr_{1,EP}$	**27.60**
Target recommended value	(kWh/m^2)	$Qr_{2,EP}$	**13.80**
Assessment of the building according to STN 73 0540 - 2		$Q_{EP} \leq Q_{N,EP}$	**Satisfactory**

By implementing construction measures **TO MEET THE REQUIREMENTS OF STN WITHOUT RECUPERATION**, it is possible to save **29.86%** of energy on heating, which represents **141.472** MWh of thermal energy.The energy and economic assessment of the proposed modifications is summarized in the table:

Table - Economic assessment of Measure 1 CONSTRUCTION MODIFICATIONS

CONCLUSION - ENERGY CONSUMPTION		kWh	473,720
energy BEFORE =	energy AFTER =	kWh	332,247
	savings TOTAL =	kWh	141,473
CONCLUSION - ENERGY COSTS	costs BEFORE =	€	21,501
	costs AFTER =	€	15,080
	savings TOTAL =	€	6,421
CONCLUSION - COST MEASURES		€	175,348

6. PROPOSAL FOR MEASURES TO REDUCE ENERGY CONSUMPTION - TECHNICAL EQUIPMENT IN THE BUILDING

Measure 2: MODIFICATION of the LIGHTING system

THE PROPOSED MEASURES

- **replacing the lighting in the object AB with LED lighting RECOMMENDED**
- **installing photovoltaic panels RECOMMENDED**

- replacing the original fluorescent lamps T8 1x36W, 2x36W, 4 x 18W and 4x36W with a classic ballast for fluorescent lamps T5 (1x18W, 2x18W) with an electronic ballast,

- replacing incandescent lamps with classic 40W and 60W bulbs for lamps with LED bulbs 1x25W (16W) E27

- supplying the number of lamps to meet the requirements in terms of lighting intensity according to STN EN 12 464 -1 Lighting of workplaces, reconstruction of motor and lighting wiring.

- installing of photovoltaic panels (50 m^2 = 11 kWp) is for the use of BUILDING LIGHTING, HEATING and HOT WATER HEATING. The costs of photovoltaics and the energy profit are divided between the distribution points!

The energy and economic assessment of the proposed modifications is summarized in the table:

Table - Economic assessment of Measure 2 LIGHTING

CONCLUSION - ENERGY CONSUMPTION			
energy BEFORE =		kWh	29,018
	energy AFTER =	kWh	5,206
	savings TOTAL =	kWh	23,812
CONCLUSION - ENERGY COSTS	costs BEFORE =	€	4,562
	costs AFTER =	€	818
	savings TOTAL =	€	3,743
CONCLUSION - COST MEASURES		€	24,670

Measure 3: MODIFICATION OF THE HEATING SYSTEM

THE PROPOSED MEASURES

- recovering the ventilation RECOMMENDED
- hydraulic regulating of the heating system NOT RECOMMENDED
- reconstructing of the heating distribution NOT RECOMMENDED
- installing solar hot water NOT RECOMMENDED
- replacing/reconstructing of the heat source RECOMMENDED
- equipment drive (recovery fans) RECOMMENDED
- installing photovoltaic panels RECOMMENDED
- equipment service and inspections (increase costs) RECOMMENDED

- Installing recuperation in classrooms in order to reduce energy requirements for air heating and providing hygienic air exchange in the premises of the building is recommended. The assumed area ventilated by recuperation is 80%, considered efficiency of recuperation is 85%.

- Hydraulic regulation of the heating distribution was already implemented, which involves the installation of thermostatic valves on radiators and control valves at heating lines.

- The reconstruction of the distribution means to implement new thermal insulation on the connecting distribution between the buildings and the boiler room and in the building. This will reduce the heat loss of the heat distribution system. The pipes are led through the heated spaces, so that the heat loss of the distribution systems contribute to the heating. Overheating is prevented by thermostatic heads on radiators.

- Solar hot water system to support heating - in this case, this measure is ineffective.

- Due to the technical condition of the heat source (gas boiler room), which is still in satisfactory condition, the replacement of boilers, nor the replacement of pumps and mixing nodes for equithermal regulation of branches is not recommended. In order to achieve energy class A0, adding electric-driven air-to-water heat pumps to the building (heat supply at the level of 85%) is suggested. The existing gas boilers shall provide the missing thermal energy (approx. 15%).

- By installing recuperation, it is necessary to provide energy to drive fans. Fans are a forced investment with no return.

-Installation of photovoltaic panels to supply electricity to drive heat pumps. Proposed area 250 m^2 = 54 kWp.

The energy and economic assesment of the proposed modifications is summarized in the table:

Table - Economic assesment of Measure 3 HEATING

CONCLUSION - ENERGY CONSUMPTION		kWh	365,761
energy BEFORE =	energy AFTER =	kWh	63,584
	savings TOTAL =	kWh	302,177
CONCLUSION - ENERGY COSTS	costs BEFORE =	€	18,585
	costs AFTER =	€	8,751
	savings TOTAL =	€	9,834
CONCLUSION - COST MEASURES		€	363,912

Measure 4: MODIFICATION of the HOT WATER HEATING system

THE PROPOSED MEASURES

- **reconstructing of distribution lines RECOMMENDED**
- **hydraulic regulating of hot water DISTRIBUTION system NOT RECOMMENED**
- **reconstructing/replacing of the hot water tank NOT RECOMMENDED**
- **solar hot water for heating hot water NOT RECOMMENDED**
- **replacing the hot water HEATING source RECOMMENDED**
- **device drive (forced by the source installation) NOT RECOMMEND**
- **installing photovoltaic panels RECOMMENDED**
- **equipment service and inspection (increase costs) RECOMMENDED**

- Reconstruction of pipelines includes designing new pipelines from the sources (electric storage heaters) and insulating them thermally. Disconnecting of the remote sinks from the source of the hot water distribution and implementing electric flow heating is recommended. The total length of circulation distribution lines will be reduced.

- Hydraulic regulation is possible only with extensive distribution systems with circulation. In the assessed building, the pipelines are short without the possibility of regulation.

- Keep the original hot water tank.

- Supplementing the TV heating source (gas boilers to be supplemented with electric air-to-water heat pumps. Heat supply ratio is 40% gas boilers and 60% heat pumps.

- Drive of other additional devices caused by other measures. They are not necessary.

- Add photovoltaic panels to drive heat pumps for heating water. The proposed area is 50 m^2 = 11kWp. The costs of installing photovoltaics are proportionally divided between among lighting, AC and hot water heating.

The energy and economic assessment of the proposed modifications is summarized in the table:

Table - Economic assessment of Measure 4 TV HEATING

CONCLUSION - ENERGY CONSUMPTION		kWh	**87,343.20**
energy BEFORE =	energy AFTER =	kWh	**44,540.56**
	savings TOTAL =	kWh	**42,802.64**
CONCLUSION - ENERGY COSTS	costs BEFORE =	€	**4,625**
	costs AFTER =	€	**3,650**
	savings TOTAL =	€	**975**
CONCLUSION - COST MEASURES		**€**	**17,556**

Measure 5: ENERGY MANAGEMENT OF THE FACILITY OPERATION

THE PROPOSED MEASURES

-Energy management RECOMMENDED

The proposed measure in the field of energy process controlshall be marked by the general term - energy management, which can save up to 10% of the energy. The proposed measures require almost no investment costs or only minimal ones. By applying the measures in the operation of the heat sources and distribution systems, it is possible to achieve savings in energy and the cost of their purchase. It is difficult to accurately calculate achievable savings, because these measures strongly depend on the individual approach of responsible workers. The calculation of possible measures is presented in this report as an example for managers and senior managers.

The measure can only be applied once the ownership of the entire site shall be acquired.

7. RECOMMENDATION OF THE OPTIMAL SOLUTION - PACKAGE OF MEASURES

From the proposed measures the overall recommended measure of the project to reduce the energy demand of the administrative building is compiled. The proposed measures are based on the assessment of the current state of the building and its energy demand, including calculations, legislative and normative criteria, as well as, consultations with the investor. The following summary measure is proposed:

A combination of the above-mentioned measures, namely total renovation of the building according to measure 1, replacement of the lighting system, subsequent modernization of the heat preparation and distribution system for heating, and the hot water preparation system. The calculations show that the combination of measures 1, 2, 3, 4, and 5 is the most advantageous financially, energetically, and environmentally. In addition, the technical measures are justified and are definitely recommended for implementation.

The condition of the proposed measures is to achieve the assessment of the individual places of energy consumption into class "B", and total primary energy into class "A0".

Table - Energy economic summary of the proposed measures

Measure	Energy saving (kWh/year)	Energy cost savings (€/year)	Investment costs without VAT (€)
M 1 = Total renovation of the building envelope	141,473	6,421	175,348
M 2 = Installation of a more energy-efficient lighting system	23,812	3,743	24,670
M 3 = Modernization of the heating system	302,177	9,834	363,912
M 4 = Modernization of the hot water preparation system	42,803	975	17,556
M 5 = Energy management of the object´s operation	0	0	0
In sum (TOTAL)	**510,264**	**20,973**	**581,486**

Table - Results of the economic assessment of the proposed measures

Investment costs for the implementation of measures without VAT (€)	**581,485.81**
Annual energy savings (kWh/year)	**510,264.14**
Annual energy savings (%) (TOTAL = H + HW + L)	**81.8%**
Annual savings in energy costs (€)	**20,973.36**
Lifetime of the measures (years)	**25.00**
Simple payback period (years) WITHOUT SUBSIDIES	**27.72**

Energy assessment of the building

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operating time of heating was taken into account with the determined effect on a decrease of the internal temperature in the category of buildings – an administrative building. To meet the energy criterion, the specific heat demand for heating must be less than the standardized value.

Based on the conclusion from the energy audit, the proposed measures implementation is recommended with regard to energy and economic savings in operating costs. In case of requirement for meeting the criteria of energy efficiency in terms of reducing the heat demand for heating according to STN 73 0540-2:2016, funds shall be spent adequately on the renovation of the building.

Classification of the building in terms of energy consumption - AFTER THE PROPOSED MEASURES

The current state of the building does not meet the energy criteria. After the implementation of measures for the heating system, the hot water preparation and lighting, the total energy consumption is class **B**, and the building is class **A0** in terms of primary energy consumption. Only the recommended measures are included in the balance sheet. The inefficient measures are excluded from the assessment.

Table - Classification of the building according to the place of energy consumption – ***AFTER THE PROPOSED MEASURES***

Classification of the building according to the place of energy consumption								School buildings and their premises			
	A	B	C	D	E	F	G	CURRENT STATE		AFTER MEASURES	
HEATING	25	56	84	112	140	138	НАД	77.67	C	33.00	B
HOT WATER	6	12	18	24	30	36	НАД	11.77	B	11.64	B
VENTILATION AND COOLING	0	0	0	0	0	0	НАД	-	-	-	-
LIGHTING	9	18	27	36	45	54	НАД	4.28	A	0.34	A
TOTAL	43	86	129	172	215	258	НАД	93.73	C	46.09	B
	A0	A1	B	C	D	E	F				
PRIMARY	34	68	136	204	272	340	НАД	120.60	B	33.91	A0

8. ENVIRONMENTAL ASSESSMENT

Enviromental assessment was done by calculating the differences in primary energy inputs in MWh before and after the measures and their multiplying by the emission coeficients of the individual relevant pollutants. All the energy consumed for the operation of the building is adjusted on the basis of invoices from the suppliers (heating, hot water heating, lighting, cooking, operation of electrical appliances, etc.).

Energy in primary carriers:

Table - Energy in the primary carrier

TOTAL ENERGY CONSUMPTION (heating + hot water + lighting + other consumption)

Indicator	The present			After measures			Change %
	from GAS	from electricity	together	from GAS	from electricity	together	
Energy Mwh	642.66	75.00	717.66	264.15	58.95	323.10	-54.98

Table - Emissions of harmful substances

TOTAL HARMFUL EMISSIONS (heating + hot water + lighting + other consumption)

Indicator	The present			After measures			Change %
	from GAS	from electricity	together	from GAS	from electricity	together	
CO_2 t/y	128.53	26.25	154.78	52.83	20.63	73.46	-52.54
CO kg/y	42.52	33.75	76.27	17.48	26.53	44.00	-42.31
TZL kg/y	0.00	13.35	13.35	0.00	10.49	10.49	-21.41
SO_2 kg/y	0.00	66.75	66.75	0.00	52.46	52.46	-21.41
NO_x kg/y	151.03	73.35	224.38	62.08	57.65	119.72	-46.64
PM2,5 kg/y	0.00	4.01	4.01	0.00	3.15	3.15	-21.41
PM 10 kg/y	0.00	9.35	9.35	0.00	7.34	7.34	-21.41

The project of proposed energy measures is a significant local environmental benefit with the installation of photovoltaic panels with an area of 350 m^2 = with a power of 75.0 kWp.

The total energy savings for building operations is 54.98%

All monitored air pollutant emissions shall lower significantly in the future up to 52.54% for CO_2. The assessment applies to the entire school building (classrooms + gyms + workshops).

9. CONCLUSION

The aim of the energy audit is to point out the potential of energy savings in the assessed buildings, taking into account local, technical and economic factors. The auditor must also take into account the requirements of the investor.

When deciding on the advantages or disadvantages of a project, there are several factors that need to be focused on individually. On the one hand, there is the economics of the project and the return on investment, on the other hand, there is an effort to reduce the energy demand for providing thermal comfort. At present, a significant factor is the impact on the environment and the reduction of greenhouse gas production, in particular CO2. However, the economic return is sometimes in the last place when considering buildings with specific use where the operator's primary goal should be providing thermal comfort and comfort of using the building with the lowest possible operating costs.

All calculations, conclusions and recommendations are based on the assessment of energy consumption in the years 2018-2020. The level of investment costs and economic assessment were determined on the basis of price lists and qualified financial estimates.

The calculations of the energy audit show that it is possible to reduce the consumption of the total energy supplied (heating + hot water + lighting + other consumption) by 55.05% in the assessed objects. The investment costs of implementing measures include necessary and efficient energy measures that shall contribute to the reduction of total energy consumption.

After the implementation of the proposed structural and technological modifications, the building under assessment shall be classified as A0 – a building with almost zero energy demand – for the place of consumption of the global indicator - primary energy consumption.

OVERVIEW OF THE MEASURES

M 1 = Roof insulation

M 2 = Installation of more energy efficient lighting systems
= Installation of photovoltaic panels

M 3 = Recuperation of ventilated air – implementation
= Reconstruction of the heat source - supplement with electric air-to-water heat pumps
= Installation of photovoltaic panels - electricity to drive HP

M 4 = Change of hot water heating at the distribution points (electric flow heaters)
= Reconstruction of the heat source - supplement with electric air-to-water heat pumps
= Installation of photovoltaic panels - electricity to drive HP

M 5 = Energy management of the object´s operation

10. SUMMARY INFORMATION SHEET

Entity name or trade name, identification number and the seat:
Village Zborov (for the United SchoolZborov)
Zborov, Lesná 10, 086 33 Zborov
Registration number: 00322741

Name, surname and address of permanent residence or any residence of the energy auditor:
Assos. Prof. Ing. František Vranay, PhD.
Kavečianska cesta 21, 04001 Košice

A list of the measures to improve energy efficiency:
The following measures are proposed: insulation of the roof, replacement of lighting systems, installation of photovoltaic panels, installation of a recuperation unit, change of hot water distribution, installation of an air-to-water heat pump for central heating and hot water, energy management of the premises.

The estimated energy savings achieved by the proposed measures:
Considering the current use of the building and the future use of the administrative building, the adjusted internal temperature of 18.5 °C is assumed for the heat demand. In this case, the current total energy consumption before the modifications is 623 MWh/year and after the implementation of the proposed modifications is 113 MWh/year.
The savings are 510 MWh/year.

Estimated financial costs for the implementation of the measures are:
581,486 EUR without VAT

Other data:

11. DATA FILE FOR MONITORING SYSTEM

Energy audit	The United School Zborov Školská 478/14, 086 33, Zborov
Classification according to SK NACE (according to the main activity of the client of the energy audit)	85.2 Primary education
Total energy savings potential (Mwh)	394.56
A SET OF PROPOSED MEASURES TO REDUCE ENERGY CONSUMPTION	
Brief description of the proposed measures	The main object is the Primary school building. The following measures are proposed: insulation of the roof, replacement of lighting systems, installation of photovoltaic panels, installation of a recuperation unit, change of hot water distribution, installation of an air-to-water heat pump for central heating and hot water, energy management of the premises.
Costs of technologies for energy conversion and distribution (in thousands of €)	406.14
Costs of production technologies (in thousands of €)	–
Costs for reducing the energy efficiency of buildings (in thousands of €)	175.35
Other costs (in thousands of €)	–
Total costs for implementing the proposed measures (in thousands of €)	581.49

SUMMARY BALANCE DATA

	Before implementing themeasures	After implementing	the measures
Energy consumption (MWh/yr)	717.66	323.10	-394.56
Energy costs in current prices (in thousands of €)	40.96	21.26	-19.70

BENEFITS IN TERMS OF ENVIRONMENTAL PROTECTION

Pollutant/greenhouse gas	Before implementing themeasures	After implementing	the measures
Solid pollutants (t/y)	0.013	0.0105	-0.003
SO_2 (t/yr)	0.067	0.052	-0.014
SO_x (t/yr)	0.224	0.120	-0.105
CO (t/yr)	0.076	0.044	-0.032
CO_2 (t/yr)	154.782	73.461	-81.321

ECONOMIC ASSESSMENT

Cash-flow of the project (in thousands of €/year)	–	Assessement period (years)	25
		Discount rate (%)	3
Simple payback period (years)	27.72	NPV	–
Real payback period (years)	–	IRR (%)	–
Energy auditor		Assoc.Prof. Ing. František Vranay, PhD	
Signature		The date	11.2021

12. SUMMARY LETTER

ENERGY AUDIT SUMMARY SHEET	
Energy audit	The United School Zborov Školská 478/14, 086 33, Zborov
Brief description of the object	The main object is the elementary school building. I propose the following measures: insulation of the roof, replacement of lighting systems, installation of photovoltaic panels, installation of a recuperation unit, change of hot water distribution, installation of an air-to-water heat pump for central heating and hot water, energy management of the premises.

DRAFT MEASURES

	Proposed measures	Energy saving [kWh]	Investment cost [EUR]
01	1 Perimeter wall insulation	–	–
	2 Roof insulation	141,473	175,348
	3 Floor insulation	–	–
	4 Replacement of holes	–	–
	5 Ventilation through windows	–	–
	01 TOGETHER	**141,473**	**175,348**
02	1 Replacement of lighting systems	16,312	10,170
	2 Photovoltaic panels (share of use)	7,500	14,500
	02 TOGETHER	**23,812**	**24,670**
03	1 Heat recuperation	138,199	216,612
	2 Hydraulic regulation of heating	–	–
	3 Reconstruction of heating distribution	–	–
	4 Solar hot water	–	–
	5 Replacement/reconstruction of the heat source	133,278	74,800
	6 Equipment drive (pumps, fans, ...)	6,800	–
	7 Photovoltaic panels (share of use)	37,500	72,500
	8 Operation, management, service	–	–
	03 TOGETHER	**302,177**	**369,912**
04	1 Reconstruction of hot water distribution	897	2000
	2 Hydraulic hot water regulation	–	–
	3 Heat tank	–	–
	4 Solar hot water	–	–
	5 Replacement/reconstruction of HW heating sources	34,408	1,056
	6 Equipment drive (pumps, ...)	–	–
	7 Photovoltaic panels (share of use)	7,500	14,500
	8 Operation, management, service	–	–

	04 TOGETHER	42,803	17,556
05	Energy management of the area operation	–	–
	05 TOGETHER	–	–
	TOGETHER	510,264	581,486

ENERGY ASSESSMENT OF THE PROJECT

	Initial state	Proposed status	Reduction	Reduction rate
Specific heat loss due to transfer: (WK-1)	6,822.13	4,861.55	1,960.58	28.7%
Specific heat loss due to ventilation (WK-1)	3,177.08	3,177.08	–	0.0%
Total heat gain of the building (kWh)	271,061.54	266,502.77	4,558.76	1.7%
Heat demand for the central heating (kWh)	473,719.73	332,246.81	141,472.92	29.9%
Demand for primary energy for heating (kWh)	365,760.71	63,584.05	302,176.66	82.6%
Energy requirement for lighting (kWh)	29,018.14	5,206.23	23,811.92	82.1%8
Demand for energy for heating and lighting (kWh)	394,778.86	68,790.28	325,988.58	2.6%

ENVIRONMENTAL ASSESSMENT OF THE PROJECT

	Initial state	Proposed status	Reduction	Reduction rate
Annual production of emissions CO_2 [ton]	154.782	73.461	81.321	52.5%
Annual production of emissions TZL [ton]	0.013	0.010	0.003	21.4%
Annual production of emissions SO_2 [ton]	0.067	0.052	0.014	21.4%
Annual production of emissions NO_2 [ton]	0.224	0.120	0.105	46.6%
Annual production of emissions CO [ton]	0.076	0.044	0.032	42.3%

ECONOMIC EVALUATION OF THE PROJECT

	Initial state	Proposed status	Reduction	Reduction rate
Investment costs for the implementation of the measures				581,485.81
Annual energy cost savings				20,973.36
Simple investment payback period [years]				27.72

6.2 SADY NAD TORYSOU COMMUNITY

1. IDENTIFICATION DATA

Identification data of the client, the operator and the subject of the energy audit.

Identification of the customer and EA guarantor	
Company name/Name of natural person:	Village Sady nad Torysou
Legal entity:	Village
Registration number:	00324680
TIN:	2021244984
Registration:	–
Address:	Byster č. 189
Name of statutory representative:	Iveta Tomková – Mayor
Telephone:	+421 911 930 589
E-mail:	info@sadynadtorysou.sk

EA subject:	Municipal office witha community centre
Address:	Byster No. 189
Property legal relationship to the client and to the EA guarantor	Property of the municipality

The energy auditor

The identification of the energy auditor	
Company name/Name of natural person:	OON Design s.r.o.
Legal entity:	Ltd.
Registration number:	48208761
TIN:	2120102094
VAT number:	SK2120102094
Registration:	District Court Košice I., Insert number 37638/V
Address:	Slovenskej jednoty 1699/48, 040 01, Košice
Name of statutory representative:	Ing. Marek Kušnír, PhD.
Telephone:	+421 907 990 714
E-mail:	kusnir@oondesign.sk
Administrators:	
Energy auditor:	Ing. Marek Kušnír, PhD.
Co-administrator:	Ing. Anton Pitoňák, PhD.

SUBJECT OF THE ENERGY AUDIT

Purpose of energy audit

The energy audit is processed in order to determine the potential of energy savings by implementing a significant renovation of the municical office with a community centre in the village of Sady nad Torysou. The renovation is planned to finance from the Operational Programme "Quality of the Environment (OP KŽP)", Specific objective: 4.3.1: Reduction of energy consumption in the operation of public buildings.

The subject of the EA is the assessment of thermal and technical properties of building structures, the energy consumption assessment of current technical systems of the building, proposed measures for the significant or in-depth renovation of the building, proposed measures for the reconstruction and modernization of technical systems in the building, determination of energy saving potential, economic and environmental assessment of proposed measures.

The energy audit is intended for the owner of the building for the needs of the owner´s decision on the possibilities of implementing the proposed measures, for the possibilities of implementing recommendations for improving the energy efficiency of the building, and as a basis for the preparation of project documentation for the building renovation.

Identification of the subject of the energy audit

The assessed building of the municipal office with a community centre is located in the outskirts of the village - Sady nad Torysou, in the cadastral area Byster, parc. no. 307/6, district Košice - surroundings.

Figure 1 Location of the energy audit object based on a satellite map

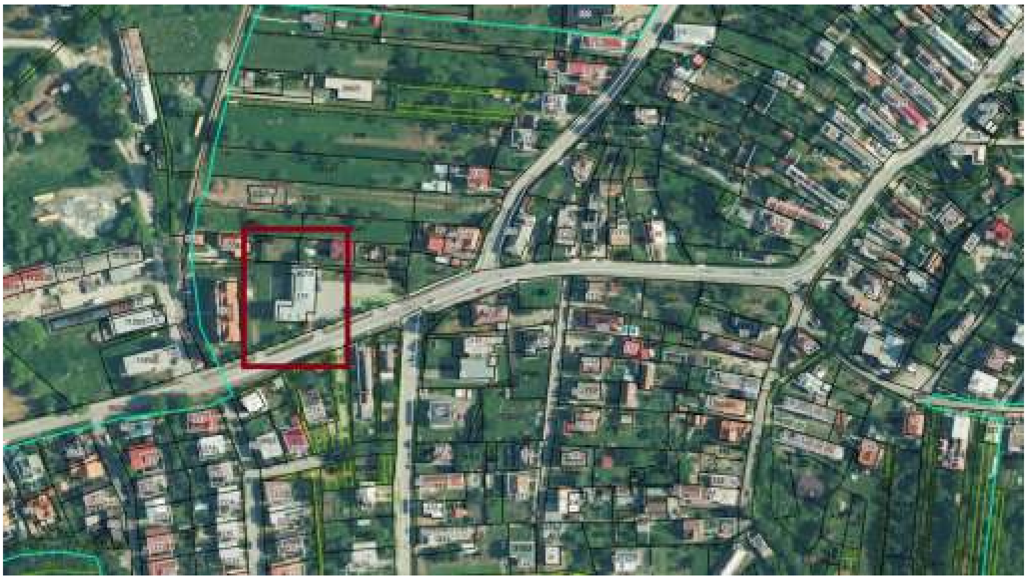


Figure 2 Location of the energy audit object based on a satellite map

Analysis of the current state

Use of the building:
3 - Office building - 100%
The assessed building is situated in the outskirts of the village of Sady nad Torysou. The building is used as a municipal office with a community centre. The building is made of CDm bricks, consists of two parts - a three-storey municipal office with a post office (MO) and a two-storey community centre (cultural house) (CC), the west side of the building was later extended with a one-storey gas control station with its own entrance. The roofs are gabled with a non-habitable loft, with three dormers in the MO part of the roof.

The building is partially reconstructed, the perimeter walls are insulated and the window and external door structures are replaced. The building has significant heat losses despite the insulation, which was installed unprofessionally together with the plastic windows and the eave system, there is also leakage and the insulation of the plinth is insufficient. The structural system is made of CDm bricks, the ceiling in the part of the MO building is wooden beamed, insulated with heat-insulating boards based on mineral wool of 100 mm. The rings and lintels are made of monolithic reinforced concrete.

After years of operation, the building requires a comprehensive reconstruction in order to improve its thermal-technical conditions and to increase the safety of the building structures of the building.

The specific floor area of the buildings is 1,129.28 m^2, the building form factor is 0.48.

Table 1 Building operation mode

Number of working days per year	250
Number of working days per week	5
Number of shifts per day	1
Length of working time	8
Use of the facility	Public building

Heating: the building is supplied with heat for heating by a gas boiler, which is located in the boiler room of the assessed building. The main heating pipes of the building are laid freely alongside the building structures or are directly built into the building structures. The heating water distribution pipework is two-pipe symmetrical with forced circulation. The piping is made of steel. The heating distribution is partially insulated with PE insulation. The fall is designed in the direction of the boiler, the pipeline blow-off is at the highest points of the heating system and discharge is at the lowest points of the heating system. Heating is provided by a convection system using radiators. The heating system is not hydraulically regulated. The condition of the heating system corresponds to the period of operation.

Hot water preparation: hot water preparation in the assessed building is solved by electric hot water heaters and flow-through hot water heaters. There is no hot water circulation in the building. The hot water pipes are installed in the heated areas of the building. The hot water pipes are made of plastic pipes and are partially insulated. The condition of the hot water preparation system corresponds to the period of operation.

Lighting: This is a municipal office building with social and technical facilities. The lighting system underwent a complex reconstruction in the past, where the original electrical unit board, fuses, circuit breakers and other components, sockets and luminaires were replaced with LED technology with a power of 30W.

Lighting energy consumption - current status
Average building occupancy factor (Fo): 0.7
Operating hours: 8 hours/day, 5 days/week (2,580 hours/year)
Annual lighting energy consumption - calculation: 10,640.76 kWh/year
Annual energy consumption for lighting - Actual: 10,461.00 kWh/year
Annual lighting costs (price 0.202 €/kWh): 2,109.58 excluding VAT

BASIC DATA ON ENERGY INPUTS AND OUTPUTS

In the subject of the energy audit, only energy inputs and energy consumption occur, energy outputs are not realised. Electricity is purchased from the supplier Východoslovenská energetika a.s. (VSE) and natural gas from Slovenský plynárenský priemysel, a.s. (SPP).

The volumes of purchased energy carriers for the monitored years were as follows:
Electricity consumption:

Table 2 Summary data on electricity consumption

Electricity	Year			3-year average (EUR)
	2017	2018	2019	
Consumption kWh/year:	11,813	11,577	11,480	11,623.33
Costs €/year:	2,112	2,403	2,517	2,343,98
Average price €/kWh	0.179	0.208	0.219	0.202

In the monitored years, the average electricity consumption reached 11.62 MWh/year what represents annual electricity costs of €2,343.98 at an average price of €0.202/kWh.

The evolution of electricity consumption and costs over the monitored years is shown in the following graphs, where the fluctuation of consumption around the average value is obvious.

3 Overview of heating consumption including partial costs

GAS	Year			3-year average (EUR)
	2018	2019	2020	
Consumption kWh/year:	642,850	734,910	550,220	**642,660**
Costs €/year:	23,808	36,260	27,440	**29,169**
Average price €/kWh:	0.0370	0.0493	0.0499	**0.0454**

Electricity consumption (kWh)

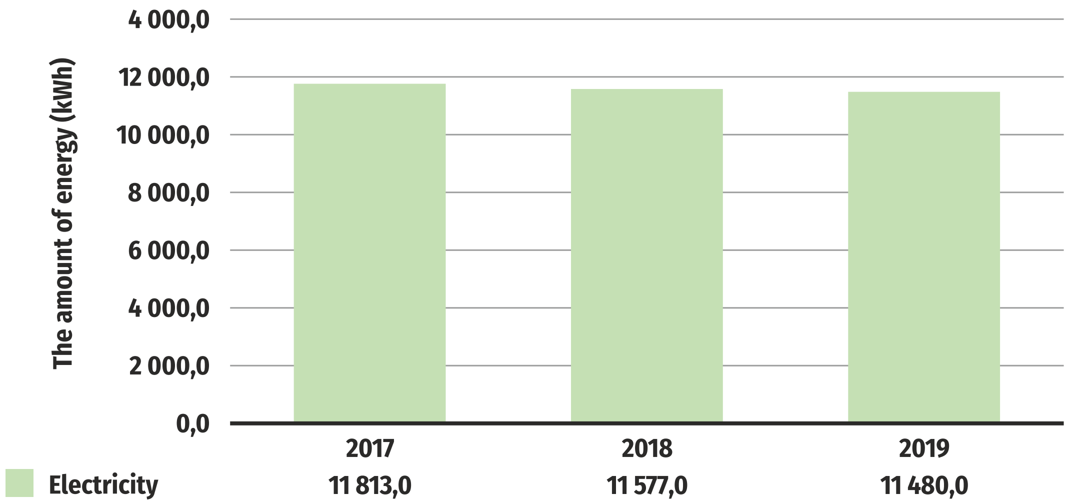


Figure 3 Electricity consumption graphs in years 2017 – 2019

Electricity costs (€)

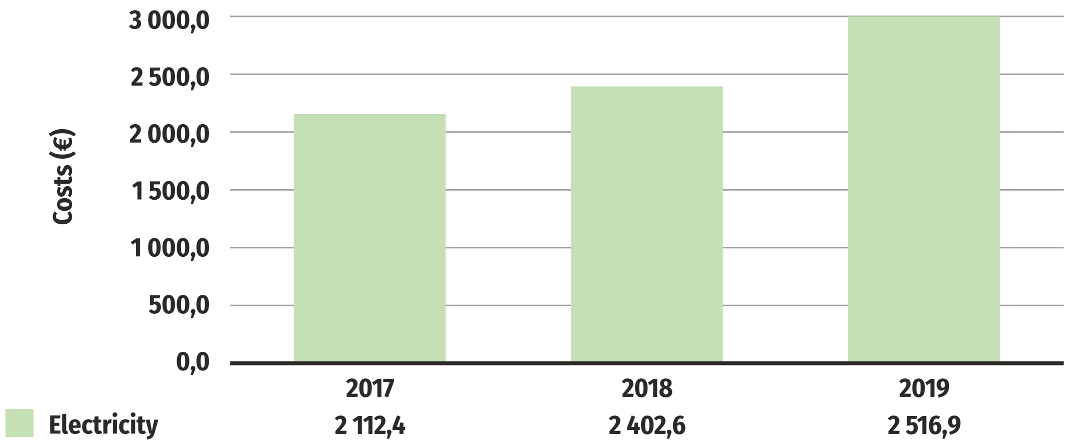


Figure 4 Annual electricity costs in years 2017 – 2019

Gas consumption for heating

Heat is generated in the building by a stationary gas boiler. An overview of natural gas consumption for heating, including partial costs, is given in the following tables:

Table 3 Overview of heating consumption including partial costs

GAS	Year			3-year average (EUR)
	2017	2018	2019	
Consumption kWh/year:	124,770	82,392	95,578	**100,913**
Costs €/year:	6,960	6,253	5,266	**6,159.5**
Average price €/kWh:	0.056	0.076	0.055	**0.062**

The evolution of the cost of natural gas over the monitored years is shown in the following graph.The average price for the monitored years is calculated at €0.062/kWh.

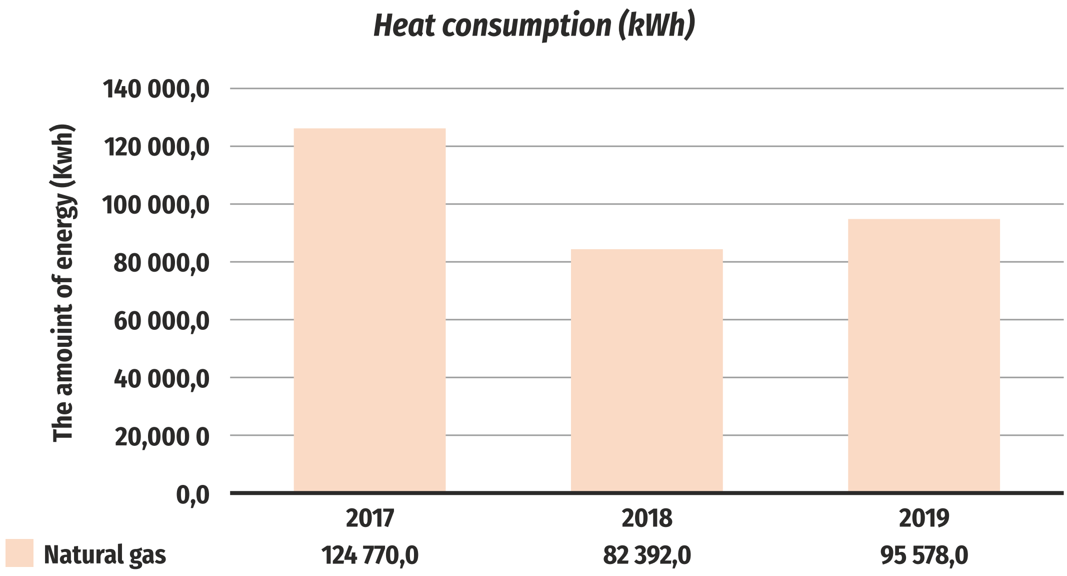


Figure 5 Overview of natural gas consumption in years 2017 – 2019

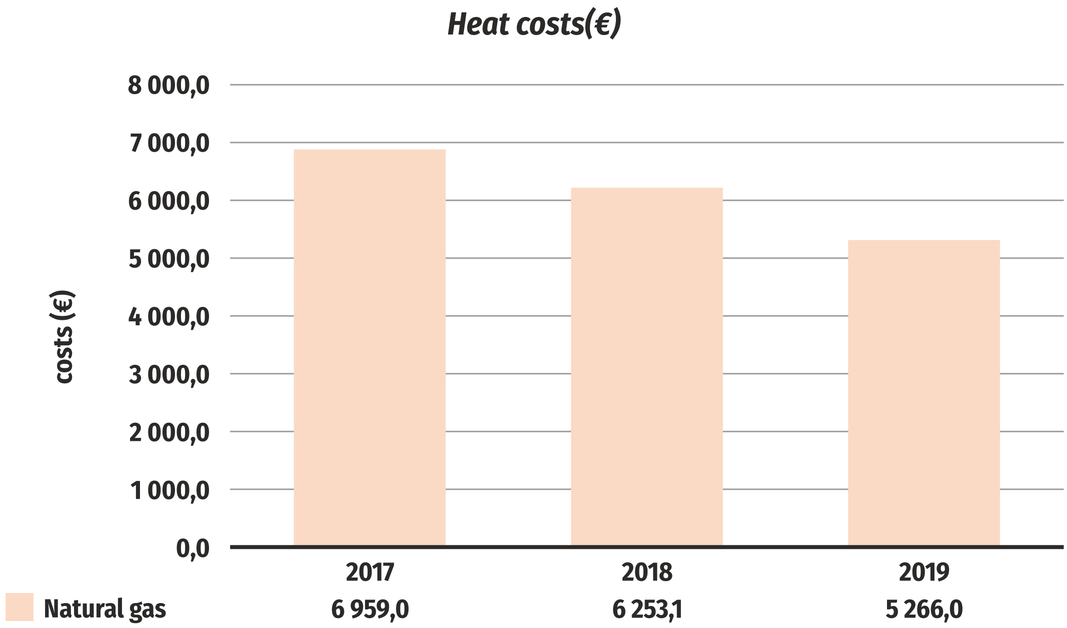


Figure 6 Annual cost of natural gas in years 2017-2019

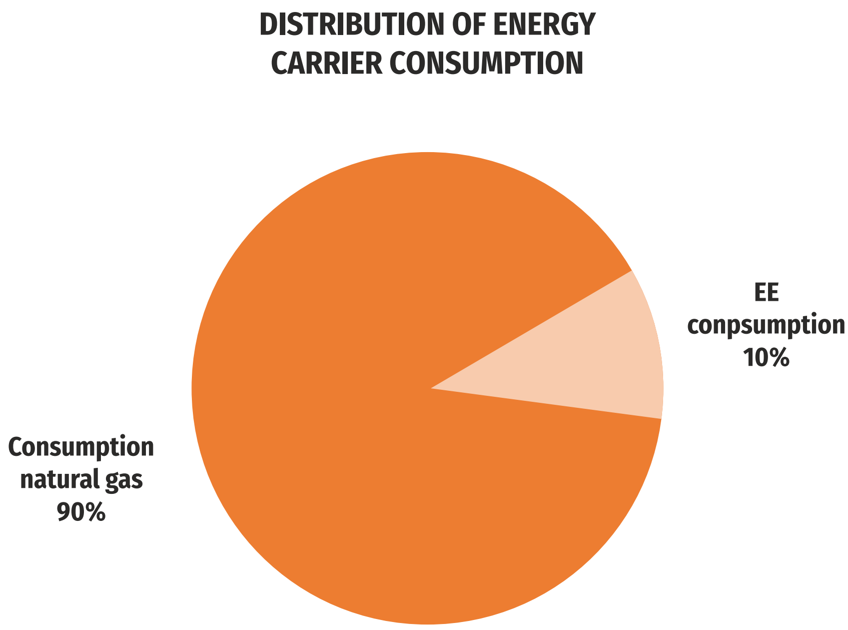
The average consumption of natural gas in the power units during the monitored years is 100.91 MWh/year at a price of 0.062 €/kWh.

The energy intensity of production includes all technological processes.

The overall structure of the energy consumption according to the invoices submitted is at 10% in terms of electricity consumption, however, in terms of energy payments, electricity costs represent 28% of the total energy costs.

Table 4 Energy input data

Fuel and energy inputs	Unit	Quantity	Heating value MWh/unit	Energy content [Mwh]	Annual costs [EUR]
Purchase of electricity	Mwh	11.62		11.62	2,343.98
Purchase of heat	Mwh				
Natural gas	Mwh	100.91		100.91	6,159.54
Lignite	t				
Coal	t				
Coke	t				
Other solid fossil fuels	t				
Heavy fuel oil	t				
Light fuel oil	t				
Biomass	t				
Oil	t				
Other energy gases	tis. m_N^3				
Secondary energy	GJ				
Renewable energy sources	Mwh				
Other fuels	t				
Total fuel and energy inputs				**112.54**	**8,503.52**
Change in fuel stocks					
Total fuel and energy inputs					**8,503.52**



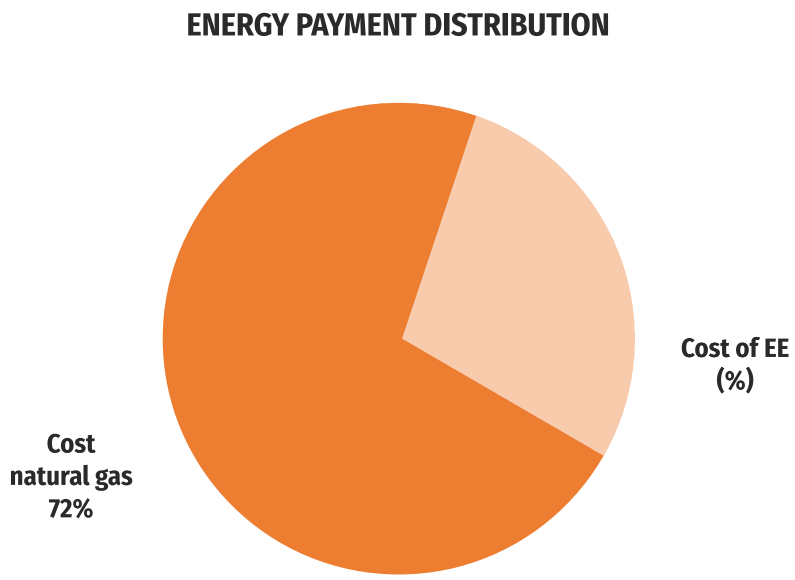


Figure 7 Graphical representation of the distribution of energy consumption and payments

THERMAL TECHNICAL ASSESSMENT OF ENVELOPE STRUCTURES, ENERGY ASSESSMENT

Local and standardized climatic conditions

The methodology based on heating day degrees was used to calculate the heat demand to cover heat loss due to heat transfer and ventilation. In the following, the data for the monitored years are presented.

Table 5 Overview of climate data for the monitored years

Calendar year	2017	2018	2019
Number of heating days	224	190	219
Average external temperature (°C)	6.20	7.76	7.52
Number of day degrees	3,577,2	3,117.9	3,133.6

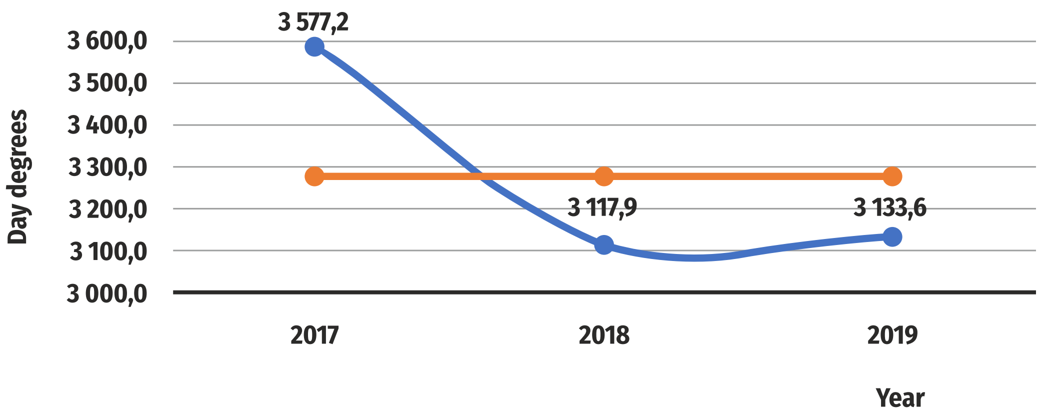


Figure 8 overview of the day degrees with the average value indicated

The heating mode of the building in real operation does not correspond to the number of day degrees in terms of the location. The heating in the building is adjusted to the building operation time, the rooms are always heated according to the need and occupancy of a room. The heating temperature of the interior spaces corresponds to the use of the building.

Table 6 Heating temperature of the space used

Use of interior space	Specific floor area A_b	Built volume V_b	Average heating temperature
	(m^2)	(m^3)	(°C)
3 – Administrative building	1,129.28	3,922.46	18.5

Standardized input data on external climatic conditions and the internal environment of the building were used to calculate the heat demand for heating purposes by the standardized assessment. The standardized assessment was used only for comparing the measured heat demand of the object according to STN 73 0540-2.

Table 7 Climatic conditions of the location

			NH	UH
Exterior calculated temperature	q_e	(°C)	-12	-13
Wind zone, wind speed	v	(m/c)	–	od 2 do 5
Interior calculated temperature	q_i	(°C)	20	18.5
φ Exterior temperature of the heating period	q_{ae}	(°C)	3.86	7.16
φ Number of heating days	d		212	211
φ Number of day degrees	D		3,422	3,276

NH - Standardized assessment
UH - Modified assessment

In the thermal technical assessment, the following conditions were taken into account, according to STN 73 0540 - 3, location of Sady nad Torysou (Košice):

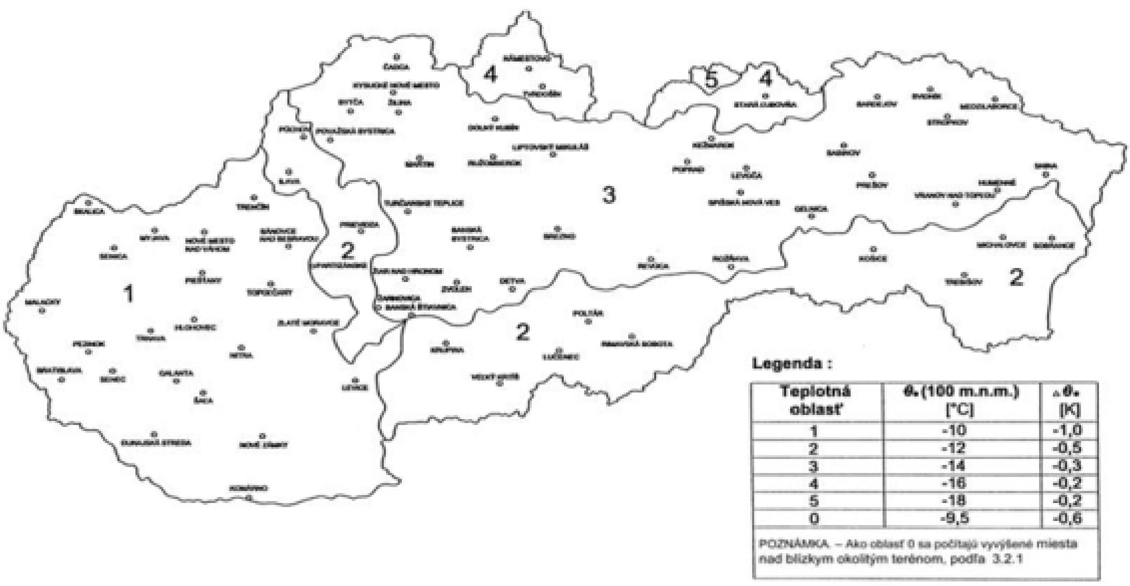


Figure 9 Division of the Slovak Republic into temperature zones

In the thermal technical calculations, the basic parameters of the building listed in the following table were used.

Table 8 Technical and geometric parameters of the building

Total built-up area [m²]	A	469.92
Perimeter of the built-up area [m]	p	107.90
Building heated volume [m³]	V_b	3,922.46
Surface area [m²]	A_b	1,129.28
Cooled envelope [m²]	ΣA_i	1,869.49
Building form factor [1/m]	$\Sigma Ai/V_b$	0.48
Number of floors above ground		3
Average floor height [m]	$hk_{,pr}$	3.47

For the thermal technical assessment of the building, the project documentation mentioned at the beginning of the report was used. The necessary details were added during the inspection of the objects and after the consultations with the investor. The following is a detailed calculation of the thermal technical assessment of the current state of the building with a description of building structures, openings, etc. The partial calculations indicate whether the item complies with the currently valid regulations and criteria for the energy efficiency of buildings.

Thermal-technical assessment of the building - current status

The sum of the areas of all solid building structures is 1,722.51 m^2. The heat transfer coefficient of the building structures is from 0.33 W.m-2.K-1 to 1.17 W.m-2.K-1. . The individual types of building structures are shown in the following table. The specific heat loss due to heat transfer within all solid building structures is 807.58 W.K-1, which represents 75.57% of the total specific heat loss due to heat transfer.

Table 9 List of fixed building structures

Building structure	Area (m²)	U ($W.m^{-2}.K^{-1}$)	U_N ($W.m^{-2}.K^{-1}$)	U_{r1} ($W.m^{-2}.K^{-1}$)	Assessment
Vertical walls above ground level					
Perimeter wall OBS 1 thickness 500 mm + 60 mm	135.21	0.43	0.32	0.22	**Unsatisfactory**
Perimeter wall OBS 2 thickness 500 mm + 100 mm	110.08	0.33	0.32	0.22	**Unsatisfactory**
Perimeter wall OBS 3 thickness 375 mm + 60 mm	4.75	042	0.32	0.22	**Unsatisfactory**

Perimeter wall OBS 4 thickness 375 mm + 100 mm	509.41	0.33	0.32	0.22	**Unsatisfactory**
Perimeter wall OBS 5 thickness 500 mm + 60 mm	13.63	0.44	0.75	0.75	**Satisfactory**
Perimeter wall OBS 6 thickness 500 mm	9.40	1.17	0.32	0.22	**Unsatisfactory**
Roof structure					
S1_Roof structure KD	280.86	0.38	0.25	0.20	**Unsatisfactory**
S2_Roof structure OcU	189.25	0.33	0.25	0.20	**Unsatisfactory**
Building structure	**Area** (m^2)	**R** ($W.m^{-2}.K^{-1}$)	**R_N** ($W.m^{-2}.K^{-1}$)	**R_{r1}** ($W.m^{-2}.K^{-1}$)	**Assessment**
Floor on the ground					
PT 1_Floor on the ground	469.92	0.09	2.30	2.50	**Unsatisfactory**

The sum of the areas of all types of openings is 146.98 m^2. The heat transfer coefficient of the openings is from 1.70 W.m-2.K-1 to 5.65 W.m-2.K-1. The individual types of opening structures are shown in the following table. The specific heat loss due to heat transfer within all openings is 261.04 W.K-1, which represents 13.47% of the total specific heat loss due to heat transfer. The perimeter masonry is fitted with multi-chamber filling structures based on PVC with insulating double glazing, but also the original wooden and metal filling structures.

Table 10 List of opening structures

Opening structure	**Area** (m^2)	**U** ($W.m^{-2}.K^{-1}$)	**Specific heat los** ($W. K^{-1}$)	**$U_{w,N}$** ($W.m^{-2}.K^{-1}$)	**$U_{w,r1}$** ($W.m^{-2}.K^{-1}$)	**Assessment**
Window construction PVC double glazing	137.46	1.70	233.68	1.40	0.85	**Unsatisfactory**
Door construction original 1	2.00	5.65	11.30	1.40	0.85	**Unsatisfactory**
Door construction original 2	2.52	3.00	7.56	1.40	0.85	**Unsatisfactory**
Door construction PVC double glazing	5.00	1.70	8.50	1.40	0.85	**Unsatisfactory**

The total area of the envelope structure is 1,869.49 m^2. The heat transfer coefficient of the envelope structure, including the specific heat loss due to thermal bridges, is 1,068.62 W.K-1. The specific heat loss due to thermal bridges is 186.95 W.K-1. According to STN 73 0540-2, meeting of the minimum requirement for the average heat transfer coefficient of the total envelope structures of the building is shown in the table.

Table 11 Average heat transfer coefficient of the building

Building form factor	Average heat transfer coefficient	Normalised value	Recommended value	Target recommended value	Assessment according to STN 73 0540-2
	U_{priem}	U_N	U_{r1}	$U_{r2, Cieľ}$	
	$(W.m^{-2}.K^{-1})$	$(W.m^{-2}.K^{-1})$	$(W.m^{-2}.K^{-1})$	$(W.m^{-2}.K^{-1})$	
0.48	0.57	0.49	0.33	0.23	**Unsatisfactory**

The share of the individual structural elements and thermal bridges in the total specific heat loss in the heat transfer is shown in the following graph.

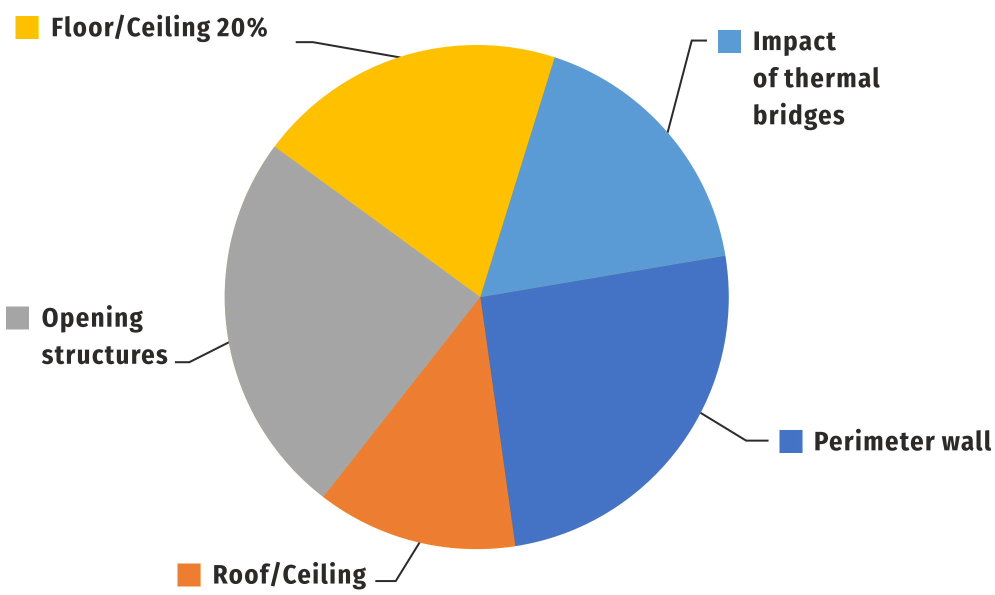


Figure 10 Distribution of the total heat loss of the building

Heat demand for heating

The calculation of the heat demand for heating was made on the basis of the calculation of the heat loss due to heat transfer within structural elements and due to ventilation, which was reduced by heat gains. The total annual heat demand to cover heat loss due to transfer and ventilation is 75,626.80 kWh.

Table 12 Heat demand for heating and corresponding calculation results

Specific heat loss due to thermal bridges	(W/K)	ΔH_{TM}	186.95
Specific heat loss heat loss between the heated space without thermal bridges	(W/K)	H_u	881.67
Specific heat loss due to transfer	(W/K)	$H_T = Hu + \Delta H_{TM}$	1,068.62
Minimum air exchange rate	(l/h)	n_{min}	0.50
Air exchange intensity due to infiltration	(l/h)	n	0.21
Average air exchange intensity	(l/h)	$n = \max(n_{min}; n_{inf})$	0.50
Volume flow rate of the mechanical ventilation system	(m^3/h)	V_f	
Volumetric air flow rate	(m^3/h)	V_v	3,922.46
Specific ventilation heat loss	(W/K)	$H_V = 0.264 . V_V$	522.47
Specific heat loss	(W/K)	$H = H_T + H_V$	1,591.09
Internal heat gain	(kWh)	Q_I	34,474.66
Passive solar gain	(kWh)	Q_S	9,613.11
Total heat gain of the building	(kWh)	$Q_g = Q_i + Q_s$	44,087.77
Heat gain utilisation factor		η	0.98
Heat demand to cover heat losses through transition	(kWh)	Q_T	**79,595.17**
Heat demand to cover heat losses through ventilation	(kWh)	Q_v	**38,915.78**
Heat demand for heating	(kWh)	Q_h	**75,626.80**

A comparison of the calculated and measured heat consumption for heating is shown in the graph.

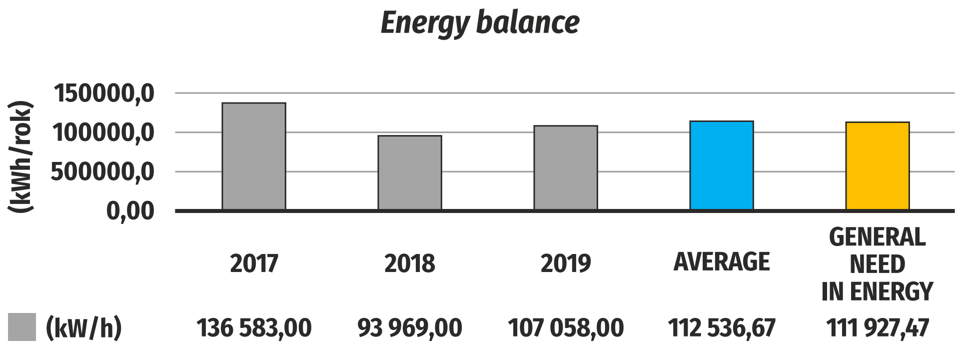


Figure 11 Comparison of measured and calculated heat consumption for heating

Based on the total annual energy demand of the public building in the pre-project condition calculated by the project energy assessment and the average measured total energy consumption of the building, the building utilisation was 100.5%.

Assessment of the building in terms of the heat demand for heating

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operating time of heating was taken into account with the determined effect on a decrease of the internal temperature in the category of buildings – an administrative building.

Table 13 Assessment of the building according to STN 73 0540-2

Building form factor	(1/m)	$\Sigma A_i/V_b$	**0.48**
CH heat demand in the reference heating seaso	(kWh)	Q_h	**75,626.80**
Specific heat demand for heating	(kWh/m^2)	Q_{EP}	**66.97**
Normalised value	(kWh/m^2)	$Q_{N,EP}$	**53.50**
Recommended value	(kWh/m^2)	$Q_{r1,EP}$	**26.80**
Target recommended value	(kWh/m^2)	$Q_{r2,EP}$	**13.40**
Building assessment according to STN 73 0540 - 2		$Q_{EP} \leq Q_{N,EP}$	**Unsatisfactory**

The assessed building does not meet the energy criterion.

Classification of the building in terms of energy consumption - current state

The current state of the building does not meet the energy criterion. In terms of heating system, hot water preparation and lighting system, the total energy requirement falls into Class **C**. In terms of primary energy consumption, the building falls into Class **B**.

Table 14 Energy demand for heating - current state

Energy consumption for HW preparation	(kWh)	Q_{TV}	**6,818**	**B**
Specific energy demand for HW preparation	(kWh/m²)	Q_{TV}	**6**	
Normalised value	(kWh/m²)	$Q_{N,\ TV}$	**8**	
Building assessment - hot water system		$Q_{TV} \leq Q_{N,\ TV}$	**Satisfactory**	

Table 16 Lighting energy demand - current state

Energy requirement for lighting	(kWh)	Q_{OSV}	**10,641**	**A**
Specific energy demand for lighting	(kWh/m²)	Q_{OSV}	**9**	
Normalised value	(kWh/m²)	$Q_{N,OSV}$	**30**	
Building assessment - lighting		$Q_{OSV} \leq Q_{N,OSV}$	**Satisfactory**	

Table 17 Total energy demand - currentstate

Total specific energy demand	(kWh/y)	Q_C	**111,927**	**C**
Total specific energy demand	(kWh/m²)	Q_C	**99**	
Normalised value	(kWh/m²)	$Q_{N,C}$	**94**	
Building assessment - total energy demand		$Q_C > Q_{N,C}$	**Satisfactory**	

Table 18 Primary energy - current state

Specific energy demand total primary	(kWh/ y)	Q_{cprim}	**145,203**	**B**
Specific energy demand total primary	(kWh/m²)	Q_{Cprim}	**129**	
Normalised value	(kWh/m²)	$Q_{N,Cprim}$	**45**	
Building assessment - primary energy		$Q_{Cprim} > Q_{N,Cprim}$	**Satisfactory**	

The assessed building does not meet the primary energy requirement.

PROPOSAL FOR MEASURES TO REDUCE ENERGYCONSUMPTION - BUILDING MODIFICATIONS AND THEIR ECONOMIC AND ENVIRONMENTAL ASSESSMENT

The following measures were proposed to reduce the energy demand of the building, which is the subject of the energy audit. The results of energy and economic calculations, as well as, the operational parameters of the building, its method and time of use were taken into account to design the measures. For the assessment of energy consumption reduction, the percentage rate of reduction in the energy demand of the building, determined by calculations based on the real energy consumption of the used technology, is taken into account. The monetary value of energy savings with an annual update rate of 2.5% shall be used in the calculation of the rate of return. All measures are energetically and economically assessed based on the average values of the energy and economic demands of building operation time for the years 2018-2020. The real discount rate, taking into account the annual inflation rate, was set at 3.0%. The amount of the investment costs was determined on the basis of the price lists and on the basis of the usual prices for proposed equipment and work.

Thermal insulation was designed to meet the required values of heat transfer coefficients, while technical feasibility was also taken into account.

Measure 1

In this measure, I propose insulation of the external wall with a thermal insulator based on mineral wool thickness of 180 mm; insulation of the external wall with a thermal insulator based on XPS thickness of 100 mm; insulation of the roof structure with a thermal insulator based on mineral wool thickness of 300 mm; replacement of the original infill structures with new plastic windows and doors with triple glazing; application of forced ventilation with heat recovery unit with an efficiency of min. 85% air volume of approx. 70%.

Insulation implies an assessment of the current state of the structures, their possible renovation and subsequent insulation. The mentioned materials are intended only as an example for easier orientation when selecting the thermo-technical properties of the insulation system.

Table 19 Calculation of heat demand for heating after the implementation of measure 1

Specific heat loss due to thermal bridges	(W/K)	ΔH_{TM}	95.81
Specific heat loss heat loss between the heated space without thermal bridges	(W/K)	H_u	548.77
Specific heat loss due to transfer	(W/K)	$H_T = Hu + \Delta H_{TM}$	644.57
Minimum air exchange rate	(l/h)	n_{min}	0.50
Air exchange intensity due to infiltration	(l/h)	n	0.20
Average air exchange intensity	(l/h)	$n = \max(n_{min}; n_{inf})$	0.50
Volume flow rate of the mechanical ventilation system	(m^3/h)	V_f	2,872.13
Volumetric air flow rate	(m^3/h)	V_v	4,103.04
Specific ventilation heat loss	(W/K)	$H_V = 0.264 . V_V$	283.13
Specific heat loss	(W/K)	$H = H_T + H_V$	927.70
Internal heat gain	(kWh)	Q_I	35,144.75
Passive solar gain	(kWh)	Q_S	7,317.44
Total heat gain of the building	(kWh)	$Q_g = Q_i + Q_s$	42,462.19
Heat gain utilisation factor		η	0.94
Heat demand to cover heat losses through transition	(kWh)	Q_T	**48,010.30**
Heat demand to cover heat losses through ventilation	(kWh)	Q_v	**21,088.45**
Heat demand for heating	(kWh)	Q_h	**29 362.48**

Energy and economic assessment of the proposed Measure 1

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operation time of heating was taken into account with the determined effect on a decrease of the internal temperature during intermittent operation in the relevant category of buildings. In order to demonstrate achieving the energy efficiency of the building, the specific heat demand for heating should be lower than the standardized value. The results of the assessment are shown in the table.

Table 20 Assessment of the building according to STN 73 0540-2 – proposed state

Building form factor	(1/m)	$\Sigma A_i/V_b$	**0.47**
UK heat demand in the reference heating season	(kWh)	Q_h	**2,9362.48**
Specific heat demand for heating	(kWh/m^2)	Q_{EP}	**25.51**
Normalised value	(kWh/m^2)	$Q_{N,EP}$	**53.50**
Recommended value	(kWh/m^2)	$Q_{r1,EP}$	**26.80**
Target recommended value	(kWh/m^2)	$Q_{r2,EP}$	**13.40**
Building assessment according to STN 73 0540 - 2		$Q_{EP} \leq Q_{N,EP}$	**Satisfactory**

By implementing construction measures it is possible to save **86.50%** of energy, which represents **87.29 MWh** of thermal energy.

Energy and Economic assessment of Measure 1 - CONSTRUCTION MODIFICATIONS

Table 21 Energy assessment of measure 1

Specific heat loss through transition (W.K-1)	(W/K)	**644.57**
Average air change rate (h-1)	(l/h)	**0.50**
Specific heat loss through ventilation (W.K-1)	(W/K)	**283.13**
Specific heat loss (W.K-1)	(W/K)	**927.70**
Internal heat gains (kWh/year)	(kWh/year)	**35,144.75**
Passive solar gains (kWh/year)	(kWh/year)	**7,317.44**
Total building heat gain (kWh/year)	(kWh/year)	**42,462.19**
Heat demand for heating (kWh/year)	(kWh/year)	**29,362.48**

Table 22 Economic evaluation of measure 1

Investment cost for the implementation of the measure without VAT (€)	**254,785.20**
Annual energy savings (kWh/year)	**87,289.90**
Annual energy savings (%)	**86.50**
Annual energy cost savings (€)	**4,116.03**
Measure lifetime (years)	**30.00**
Simple payback period (years)	**61.90**

PROPOSAL FOR MEASURES TO REDUCE ENERGY CONSUMPTION - TECHNICAL EQUIPMENT IN THE BUILDING

Measure 2:Modernisation of the heating system

Heating system: the current heat distribution system for the heating system does not meet the current energy conditions and therefore we propose to change the original heating system in the building under consideration. The change of the heat distribution system includes the installation of thermostatic valves, which will be properly preset according to the design of the hydraulic regulation of the entire heating system. The heat source in the form of a gas boiler is proposed to be replaced with a new electric pump that will meet the current energy requirements.

Hot water system: The hot water in the building under consideration is currently produced by electric heaters. The current hot water distribution system does not meet current requirements. The replacement of the hot water source in the form of electric heaters with a new local electric pump that will meet the current energy requirements is proposed.

Energy and economic assessment of the proposed technical measure

The implementation of the proposed technical measure itself can save 74.78 % of heat energy on heating, which represents 75.47 MWh of heat per year. We consider a saving of the calculated heat demand for heating compared to the original one in the case of the implementation of this variant only. If the selected measure is implemented, the above savings need to be applied to the actual heat demand. This energy saving is included in the calculation of the comprehensive renovation of the building in measure 1.

The energy and economic assessment of the proposed modifications is summarized in the table:

Table 23 - Economic assessment of Measure 3

Investment cost for the implementation of the measure without VAT (€)	**98,500.00**
Annual energy savings (kWh/year)	**75,466.35**
Annual energy savings (%)	**74.78**
Annual energy cost savings (€)	**4,606.31**
Measure lifetime (years)	**25.00**
Simple payback period (years)	**21.38**

RECOMMENDATION OF THE OPTIMAL SOLUTION - PACKAGE OF MEASURES

From the proposed measures the overall recommended measure of the project to reduce the energy demand of the administrative building is compiled. The proposed measures are based on the assessment of the current state of the building and its energy demand, including calculations, legislative and normative criteria, as well as, consultations with the investor. The following summary measure is proposed:

A combination of the above-mentioned measures, namely total renovation of the building according to measure 1, subsequent modernization of the heat preparation and distribution system for heating, and the hot water preparation system. The calculations show that the combination of measures 1 and 2 is the most advantageous financially, energetically, and environmentally. In addition, the technical measures are justified and are definitely recommended for implementation.

Table 24 - Energy economic summary of the proposed measures

Measure	Energy saving (kWh/ year)	Savings on energy costs (€/year)	Investment costs excluding VAT (€)
Complex renovation of the building's outer shell with replacement of the openings, roof insulation and floor insulation + HVAC recuperation	87,290	4,116	254,785
Modernisation of the heating and hot water system (savings included in the complex renovation of the building)	75,466	4,606	98,500
Total	**87,290**	**4,116**	**353,285**

Table 25 Results of the economic assessment of the proposed measure

Investment cost for the implementation of the measure without VAT (€)	**353,285.20**
Annual energy savings (kWh/year)	**87,289.90**
Annual energy savings (%)	**78%**
Annual energy cost savings (€)	**4,116.03**
Measure lifetime (years)	**25.00**
Simple payback period (years)	**85.83**

Energy assessment of the building

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operating time of heating was taken into account with the determined effect on a decrease of the internal temperature in the category of buildings – an administrative building. To meet the energy criterion, the specific heat demand for heating must be less than the standardized value.

Building form factor	(1/m)	$\Sigma A_i/V_b$	**0.47**
CH heat demand in the reference heating season	(kWh)	Q_h	**29,362.48**
Specific heat demand for heating	(kWh/m^2)	Q_{EP}	**25.51**
Normalised value	(kWh/m^2)	$Q_{N,EP}$	**53.50**
Recommended value	(kWh/m^2)	$Q_{r1,EP}$	**26.80**
Target recommended value	(kWh/m^2)	$Q_{r2,EP}$	**13.40**
Building assessment according to STN 73 0540 - 2	(kWh/m^2)	$Q_{EP} \leq Q_{N,EP}$	**Satisfactory**

The building meets the energy consumption criterion in terms of heat demand for heating according to STN 73 0540-2 + Z1 + Z2: 2019.

Based on the conclusion from the energy audit, the proposed measures implementation is recommended with regard to energy and economic savings in operating costs. In case of requirement for meeting the criteria of energy efficiency in terms of reducing the heat demand for heating according to STN 73 0540-2+ Z1 + Z2: 2019, funds shall be spent adequately on the renovation of the building.

CLASSIFICATION OF THE BUILDING IN TERMS OF ENERGY CONSUMPTION – THE PROPOSED MEASURES

The current state of the building does not meet the energy criteria. After the implementation of measures for the heating system, the hot water preparation and lighting, the total energy consumption is class **A**, and the building is class **A0** in terms of primary energy consumption.

Table 26 Energy demand for heating - proposed state

Energy requirement for heating	(kWh)	Q_{UK}	**34,792**	**B**
Specific energy demand for heating	(kWh/m²)	Q_{UK}	**30**	
Normalised value	(kWh/m²)	$Q_{N,UK}$	**56**	
Building assessment - heating system		$Q_{UK} \leq Q_{N,UK}$	**Satisfactory**	

Table 27 Energydemandforhotwaterpreparation - proposedstate

Energy consumption for HW preparation	(kWh)	Q_{TV}	**6,948**	**B**
Specific energy demand for HW preparation	(kWh/m²)	Q_{TV}	**6**	
Normalised value	(kWh/m²)	$Q_{N,TV}$	**8**	
Building assessment - hot water system		$Q_{TV} \leq Q_{N,TV}$	**Satisfactory**	

Table 28 Lighting energy demand - proposed state

Energy requirement for lighting	(kWh)	Q_{OSV}	**10,663**	**A**
Specific energy demand for lighting	(kWh/m²)	Q_{OSV}	**9**	
Normalised value	(kWh/m²)	$Q_{N,OSV}$	**30**	
Building assessment - lighting		$Q_{OSV} \leq Q_{N,OSV}$	**Satisfactory**	

Table 29 Total energy demand - proposedstate

Total specific energy demand	(kWh/y)	Q_C	**52,403**	**A**
Total specific energy demand	(kWh/m²)	Q_C	**46**	
Normalised value	(kWh/m²)	$Q_{N,C}$	**94**	
Building assessment - total energy demand		$Q_C \leq Q_{N,C}$	**Satisfactory**	

Table 30 Primary energy - proposed state

Specific energy demand total primary	(kWh/y)	Q_{cprim}	**51,765**	**A0**
Specific energy demand total primary	(kWh/m²)	Q_{Cprim}	**45**	
Normalised value	(kWh/m²)	$Q_{N,Cprim}$	**45**	
Building assessment - primary energy		$Q_{Cprim} \leq Q_{N,Cprim}$	**Satisfactory**	

The assessed building meets the primary energy requirement.

ENVIRONMENTAL ASSESSMENT

Enviromental assessment was done by calculating the differences in primary energy inputs in MWh before and after the measures and their multiplying by the emission coeficients of the individual relevant pollutants.

Energy in primary carriers:

Table 31 Energy in the primary carrier

Indicator	The present			After measures			Change %
	from GAS	from electricity	together	from GAS	from electricity	together	
Energy Mwh	100.91	11.62	112.54	13.62	11.62	25.25	-77.6

Table 32 Emissions of harmful substances

Indicator	The present			After measures			Change %
	from GAS	from electricity	together	from GAS	from electricity	together	
CO_2 t/r	21.40	1.94	123.34	2.28	1.94	4.22	-81.9
CO kg/r	12.49	5.23	17.72	6.13	5.23	11.36	-35.9
TZL kg/r	2.69	2.07	4.76	2.42	2.07	4.49	-5.7
SO_2 kg/r	13.47	10.34	23.82	12.12	10.34	22.47	-5.7
NO_x kg/r	34.96	11.37	46.33	13.32	11.37	24.69	-46.7
PM2,5 kg/r	0.81	0.62	1.43	0.73	0.62	1.35	-5.7
PM 10 kg/r	1.89	1.45	3.33	1.70	1.45	3.15	-5.7

A significant local environmental benefit shall be the insulation of the building, the replacement of windows and doors in transparent openings, as well as the installation of a heat recovery system together with transformation of heat distribution for the heating system.

All monitored air pollutant emissions shall lower significantly in the future from 5.7% to 81.9%.

CONCLUSION

The aim of the energy audit is to point out the potential of energy savings in the assessed buildings, taking into account local, technical and economic factors. The auditor must also take into account the requirements of the investor.

When deciding on the advantages or disadvantages of a project, there are several factors that need to be focused on individually. On the one hand, there is the economics of the project and the return on investment, on the other hand, there is an effort to reduce the energy demand for providing thermal comfort. At present, a significant factor is the impact on the environment and the reduction of greenhouse gas production, in particular CO2. However, the economic return is sometimes in the last place when considering buildings with specific use where the operator's primary goal should be providing thermal comfort and comfort of using the building with the lowest possible operating costs.

All calculations, conclusions and recommendations are based on the assessment of energy consumption in the years 2017-2019. The level of investment costs and economic assessment were determined on the basis of price lists and qualified financial estimates.

The calculations of the energy audit show that it is possible to reduce the energy consumption by 77.6% in the assessed building. The investment costs of implementing measures include necessary and efficient energy measures that shall contribute to the reduction of total energy consumption.

After the implementation of the proposed structural and technological modifications, the building under assessment shall be classified as A0 – a building with almost zero energy demand – for the place of consumption of the global indicator - primary energy consumption.

SUMMARY INFORMATION SHEET

Entity name or trade name, identification number and the seat:
Village Sady nad Torysou
Byster No. 189
Registration number: 00324680

Name, surname and address of permanent residence or any residence of the energy auditor:
Ing. Marek Kušnír, PhD.
Strážovská 10, 040 10 Košice

A list of the measures to improve energy efficiency:
The insulation of the external wall with a thermal insulator based on mineral wool thickness of 180 mm; insulation of the external wall with a thermal insulator based on XPS thickness of 100 mm; insulation of the roof structure with a thermal insulator based on mineral wool thickness of 300 mm; replacement of the original infill structures with new plastic windows and doors with triple glazing; application of forced ventilation with heat recovery unit with an efficiency of min. 85% air volume of approx. 70% . Modernization of the heating system and replacement of the heat source for hot water preparation.

The estimated energy savings achieved by the proposed measures:
Considering the current use of the building and the future use of the administrative building, the adjusted internal temperature of 18.5 °C is assumed for the heat demand. In this case, the current total energy consumption before the modifications is 112.54 MWh/year and after the implementation of the proposed modifications is 25.25 MWh/year.
The savings are 87.29 MWh/year.

Estimated financial costs for the implementation of the measures are:
353 285 eur bez DPH

Other data:

11. DATA FILE FOR MONITORING SYSTEM

Energy audit of the municipal office building in the municipality of Sady nad Torysou; Byster No. 189; 044 41 Sady nad Torysou	
Classification according to SK NACE (according to the main activity of the client of the energy audit)	Administrative building 84110
Total energy savings potential (Mwh)	87.29
A SET OF PROPOSED MEASURES TO REDUCE ENERGY CONSUMPTION	
Brief description of the proposed measures	The insulation of the external wall with a thermal insulator based on mineral wool thickness of 180 mm; insulation of the external wall with a thermal insulator based on XPS thickness of 100 mm; insulation of the roof structure with a thermal insulator based on mineral wool thickness of 300 mm; replacement of the original infill structures with new plastic windows and doors with triple glazing; application of forced ventilation with heat recovery unit with an efficiency of min. 85% air volume of approx. 70% . Modernization of the heating system and replacement of the heat source for hot water preparation.
Costs of technologies for energy conversion and distribution (in thousands of €)	98.50
Costs of production technologies (in thousands of €)	0.00
Costs for reducing the energy efficiency of buildings (in thousands of €)	254.79
Other costs (in thousands of €)	
Total costs for implementing the proposed measures (in thousands of €)	353.29

SUMMARY BALANCE DATA

	Before implementing	After implementing the measures	Difference
Energy consumption (MWh/yr)	112.54	25.25	-87.29
Energy costs in current prices (in thousands of €)	8.50	4.39	-4.12

BENEFITS IN TERMS OF ENVIRONMENTAL PROTECTION

Pollutant/greenhouse gas	Before implementing	After implementing the measures	Difference
Solid pollutants (t/r)	0.0048	0.0045	-0.0003
SO_2 (t/r)	0.024	0.022	-0.001
SO_x (t/r)	0.046	0.025	-0.022
CO (t/r)	0.018	0.011	-0.006
CO_2 (t/r)	23.340	4.216	-19.124

ECONOMIC ASSESSMENT

Cash-flow of the project (in thousands of €/year)	–	Real payback period (years)	25
Simple payback period (years)	85.8	Discount rate (%)	3
Real payback period (years)	–	NPV (in thousands of €)	–
		IRR (%)	–
Energy audito		Ing. Marek Kušnír, PhD.	
Signature		The date	11.2021

6.3 NOVÁ BAŠTA COMMUNITY

1. IDENTIFICATION DATA

Identification data of the client, the operator and the subject of the energy audit.

Identification of the customer and EA guarantor	
Company name/Name of natural person:	Obec Nová Bašta
Seat:	980 34 Nová Bašta No. 64
Registration number:	00 318 931
TIN:	2021230310
Name of statutory representative:	Richard Molnár
Authorized representative:	Richard Molnár
Contact person:	Richard Molnár
Telephone:	+42147/56 91 111, +41915497723
E-mail:	nova.basta@gmail.com
EA subject:	Budova obecného úradu
Address:	980 34 Nová Bašta No. 64
The identification of the energy auditor	
Company name/Name of natural person:	BIM designing s.r.o.
Seat:	Duklianska 641/1, 08901 Svidník
Registration number:	51131901
TIN:	2120600680
VAT number	SK2120600680
E-mail:	info@energetikabudov.sk
Administrator:	
Co-administrator	Ing. Ladislav Ťažký. PhD. Ing. Zuzana Štefancová
Energy auditor	Ing. Martin Štefanco – 321/2014 - 0067

2. SUBJECT OF THE ENERGY AUDIT

Purpose of energy audit

The energy audit is processed for the purpose of the planned implementation of a major renovation of the administrative building in the village of Nová Bašta.

The subject of the EA is the assessment of thermal and technical properties of building structures, the energy consumption assessment of current technical systems of the building, proposed measures for the significant or in-depth renovation of the building, proposed measures for the reconstruction and modernization of technical systems in the building, determination of energy saving potential, economic and environmental assessment of proposed measures.

The energy audit is intended for the owner of the building for the needs of the owner´s decision on the possibilities of implementing the proposed measures, for the possibilities of implementing recommendations for improving the energy efficiency of the building, and as a basis for the preparation of project documentation for the building renovation. The implementation project must be carried out in accordance with generally binding legislation and other contractually agreed requirements.

Identification of the subject of the energy audit

The object of the assessed school is located in the village of Nová Bašta, in Cadastral territory Nová Bašta, parc. no. 472/1, in the district of Rimavská Sobota.

Figure 1 Location of the energy audit object

3. ANALYSIS OF THE CURRENT STATE

Building use: Administrative buildng

The building on plot no. 472/1 is used as an administrative building in the village of Nová Bašta. It is situated in the central part of the village. The floor plan of the building has a rugged shape. The building is accessible from the local road via a paved area. There are mostly residential buildings, shop around the building.

It is a one-storey office building without basement with a gable and flat roof. The perimeter walls as well as the vertical load-bearing structures of the building are made of 450 mm thick brick. The horizontal structures consist of wooden beams. The surface treatment of the premises consists mainly of lime-cement plaster with painting. The sanitary rooms are provided with ceramic tiles. The external finish consists of lime-cement plaster, which is degraded in several places. The building is fitted with wooden double-glazed windows. The doors are original - wooden.

The specific floor area of the buildings is **299.09 m^2**, the building form factor is **0.854**.

Table 1 Building operation mode

Number of working days per year	251
Number of working days per week	5
Number of shifts per day	1
Length of working time	7.5
Use of the facility	Public building

Heating: Heat supply for heating is provided by a boiler for lump wood and brown coal, which is located in the utility room. The heat is supplied in the form of 70/55 °C hot water from a central source in the boiler room via a steel pipe which runs freely along the wall, in the structure or in a duct. The heating of the entire building is by a hot-water twin-pipe heating system. Heat is transferred by radiators located under the windows. The heating system is not hydraulically regulated. The condition of the heating system corresponds to the period of operation.

Hot water preparation: hot water is produced by an electric storage heater. The storage tank is located in the heated space.

Lighting: Currently, the lighting system is mainly provided by fluorescent and incandescent luminaires with switches at the entrance to a room. This lighting system is unsatisfactory in terms of the following: electrical safety - building wiring does not meet current valid standards, outdated lighting, lighting intensity, lighting technical requirements for lighting according to the currently validlighting standards, individual types of rooms and connection of luminaires with aluminium cables.

In terms of reconstruction, the luminaires shall be completely dismantled and completed.

It is an administrative building with social and technical facilities. Lighting of the premises is solved by 1x60W bulbs (technical rooms, sanitary facilities, corridor) fluorescent lamps T8 2x36W (offices, kitchen). Lighting is switched manually by switches (R1).

Wiring - electrical cabinets, fuses and fittings, sockets and switches are in original condition, are technically and morally obsolete. Also the socket and light wiring is run with aluminium wires. The minimum requirement according to STN EN 12 464-1 for office lighting is 500 lux.

Lighting energy consumption - current state
Operating hours: 7.5 hours/day, 5 days/week (1,882.5 hours/year))
Annual lighting energy consumption - calculation: 4,646.84 kWh/year
Annual energy consumption for lighting - Actual: 5,160.00 kWh/year
Annual lighting costs (price 0.245 €/kWh): 1,264.00 excluding VAT.

4. BASIC DATA ON ENERGY INPUTS AND OUTPUTS

In the subject of the energy audit, only energy inputs and energy consumption occur, energy outputs are not realised. Electricity is purchased from the supplier Stredoslovenská energetika, a.s.

The volumes of purchased energy carriers for the monitored years were as follows:
Electricity consumption:

Table 2 Summary data on electricity consumption

Electricity consumption				
YEAR	**2018**	**2019**	**2020**	**Average**
Consumption kWh/year:	5,247	5,539	4,694	**5,160.0**
Costs €/year:	1,284	1,382	1,126	**1,264.0**
Average price €/kWh	0.245	0.250	0.240	**0.245**

In the monitored years, the average electricity consumption reached 5.16 MWh/year what represents annual electricity costs of €1,264.00 at an average price of €0.245/kWh.

Gas consumption for heating

An overview of the consumption of brown coal and lump wood for heating, including sub-costs is given in the following tables:

Table 3 Overview of heating consumption including partial costs

Brown coal consumption				
YEAR	**2018**	**2019**	**2020**	**Average**
Consumption kWh/year:	21,550	17,240	17,412	**18,734.1**
Costs €/year:	716	572	717	**668.4**
Average price €/kWh:	0.033	0.033	0.041	**0.036**

Lump wood consumption				
YEAR	**2018**	**2019**	**2020**	**Average**
Consumption kWh/year:	61,248	40,832	61,248	**54,442.7**
Costs €/year:	420	420	666	**502.1**
Average price €/kWh:	0.007	0.010	0.011	**0.009**

The average heat consumption in the power units over the monitored years is 73.18 MWh/year at a price of 0.045 €/kWh.

All technological processes are included in the energy intensity of production.

The overall structure of energy consumption according to the invoices submitted is 7% for electricity, 24% for lignite and 69% for wood chunks; also in terms of energy payments, electricity, lignite and wood chunks account for 52%, 27% and 21% of the total energy costs respectively.

Table 4 Energy input data

Fuel and energy inputs	Unit	Quantity	Heating value MWh/unit	Energy content [Mwh]	Annual costs [EUR]
Purchase of electricity	Mwh	5.16		5.16	1,264.02
Purchase of heat	Mwh				
Natural gas	MWhт				
Lignite	Mwh	17.07	3.19	54.44	502.10
Coal	t	4.35	4.31	18.73	668.43
Coke	t				
Other solid fossil fuels	t				
Heavy fuel oil	t				
Biomass	t				
Light fuel oil	t				
Oil	t				
Other energy gases	tis. m_N^3				
Secondary energy	GJ				
Renewable energy sources	MWh				
Other fuels	t				
Total fuel and energy inputs				**78.34**	**2,434.55**
Change in fuel stocks					
Total fuel and energy inputs				**78.34**	**2,434.55**

5. THERMAL TECHNICAL ASSESSMENT OF ENVELOPE STRUCTURES, ENERGY ASSESSMENT

Local and standardized climatic conditions

The methodology based on heating day degrees was used to calculate the heat demand to cover heat loss due to heat transfer and ventilation. In the following, the data for the monitored years are presented.

Table 5 Overview of climate data for the monitored years

Calendar year	2018	2019	2020
Number of heating days	195	219	226
Average external temperature (°C)	7.58	7.49	7.84
Number of day degrees	2,857.8	2,825.1	2,922.7

The heating mode of the building in real operation does not correspond to the number *of day degrees* in terms of the location. The heating in the building is adjusted to the building operation time, the rooms are always heated according to the need and occupancy of a room. The heating temperature of the interior spaces corresponds to the use of the building.

Standardized input data on external climatic conditions and the internal environment of the building were used to calculate the heat demand for heating purposes by the standardized assessment. The standardized assessment was used only for comparing the measured heat demand of the object according to STN 73 0540-2.

Table 6 Climatic conditions of the location

			NH	UH
Exterior calculated temperature	q_e	(°C)	-12	-13
Wind zone, wind speed	v	(m/s)	–	od 2
Interior calculated temperature	q_i	(°C)	18.5	20
φ Exterior temperature of the heating period	q_{ae}	(°C)	3.86	7.64
φ Number of heating days	d		212	213
φ Number of day degrees	D		3,104	2,869

NH - Standardized assessment
UH - Modified assessment

In the thermal technical assessment, the following conditions were taken into account, according to STN 73 0540 - 3, location of Nová Bašta.

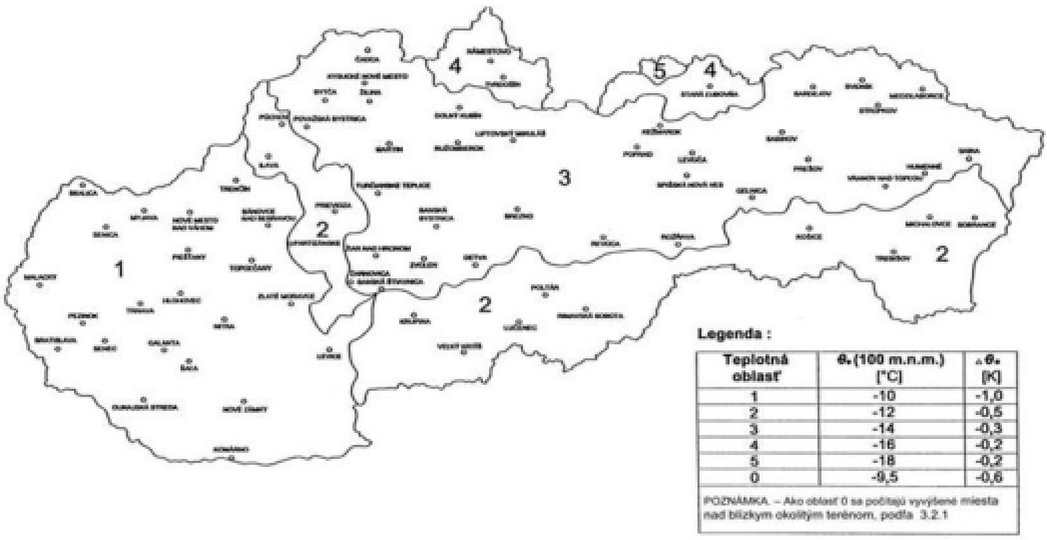


Figure 10 Division of the Slovak Republic into temperature zones

In the thermal technical calculations, the basic parameters of the building listed in the following table were used.

Table 8 Technical and geometric parameters of the building

Total built-up area [m^2]	A	299.09
Perimeter of the built-up area [m]	p	90.448
Building heated volume [m^3]	V_b	1,121.59
Surface area [m^2]	A_b	299.09
Cooled envelope [m^2]	ΣA_i	957.67
Building form factor [1/m]	$\Sigma Ai/V_b$	0.85
Number of floors above ground		1
Average floor height [m]	$hk_{,pr}$	3.75

For the thermal technical assessment of the building, the project documentation mentioned at the beginning of the report was used. The necessary details were added during the inspection of the objects and after the consultations with the investor. The following is a detailed calculation of the thermal technical assessment of the current state of the building with a description of building structures, openings, etc. The partial calculations indicate whether the item complies with the currently valid regulations and criteria for the energy efficiency of buildings.

Thermal-technical assessment of the building - current status

The sum of the areas of all solid building structures is 912.20 m². The heat transfer coefficient of the building structures is from 1.345 W.m-2.K-1 to 2.257 W.m-2.K-1.. The individual types of building structures are shown in the following table. The specific heat loss due to heat transfer within all solid building structures is 1,134.30 W.K-1, which represents 83.90% of the total specific heat loss due to heat transfer.

Table 8 List of fixed building structures

Building structure	AREA (m²)	U ($W.m^{-2}.K$-1)	U_N ($W.m^{-2}.K^{-1}$)	U_{r1} ($W.m^{-2}.K^{-1}$)	Assessment
Vertical walls above ground level					
Os1 – Perimeter wall thickness 500 mm	314.04	1,345	0,32	0,22	**Unsatisfactory**
Building structure	**AREA** (m²)	**U** ($W.m^{-2}.K$-1)	**U_N** ($W.m^{-2}.K^{-1}$)	**U_{r1}** ($W.m^{-2}.K^{-1}$)	**Assessment**
Roof structures					
S1 – Flat roof	25.67	2.257	0.25	0.2	**Unsatisfactory**
STR1 - Ceiling construction in the loft space	273.42	2.257	0.25	0.2	**Unsatisfactory**
Building structure	**AREA** (m²)	**U** ($W.m^{-2}.K$-1)	**U_N** ($W.m^{-2}.K^{-1}$)	**U_{r1}** ($W.m^{-2}.K^{-1}$)	**Assessment**
Floor on the ground					
P1 - Floor on the ground	299.09	0.054	2.3	2.5	**Unsatisfactory**

The sum of the areas of all types of openings is 45.45 m². The heat transfer coefficient of the openings is 2.70 W.m-2.K-1. The individual types of opening structures are shown in the following table. The specific heat loss due to heat transfer within all openings is 122.70 W.K-1, which represents 13.47% of the total specific heat loss due to heat transfer. The perimeter masonry is fitted with wooden double glazed windows and doors.

Table 9 List of opening structures

Opening construction	Area (m²)	U ($W.m^{-2}.K^{-1}$)	($W.K^{-1}$)	UW,R1 ($W.m^{-2}.K^{-1}$)	UW,R2 ($W.m^{-2}.K^{-1}$)	Assesment
Wooden window 1.17 x 1.80	10.53	2.70	28.43	1.00	0.85	**Unsatisfactory**
Wooden window 1.17 x 1.80	2.11	2.70	5.70	1.00	0.85	**Unsatisfactory**
Wooden window 0.78 x 0.88	0.69	2.70	1.86	1.00	0.85	**Unsatisfactory**

Wooden window 1.06 x 1.80	1.91	2.70	5.16	1.00	0.85	**Unsatisfactory**
Wooden window 1.17 x 1.47	1.72	2.70	4.64	1.00	0.85	**Unsatisfactory**
Wooden window 2.00 x 1.80	10.8	2.70	29.16	1.00	0.85	**Unsatisfactory**
Wooden window 0.56 x 0.80	0.45	2.70	1.22	1.00	0.85	**Unsatisfactory**
Wooden window 1.06 x 1.80	1.91	2.70	5.16	1.00	0.85	**Unsatisfactory**
Wooden window 1.17 x 1.47	1.72	2.70	4.64	1.00	0.85	**Unsatisfactory**
Wooden door 1.33 x 2.05	2.73	2.70	7.37	1.00	0.85	**Unsatisfactory**
Wooden door 0.88 x 2.10	1.85	2.70	5.00	1.00	0.85	**Unsatisfactory**
Wooden door 1,48 x 2,10	3.11	2.70	8.40	1.00	0.85	**Unsatisfactory**
Wooden door 0.92 x 2.08	1.91	2.70	5.16	1.00	0.85	**Unsatisfactory**
Wooden door 1.05 x 2.05	2.14	2.70	5.78	1.00	0.85	**Unsatisfactory**
Wooden door 0.92 x 2.05	1.89	2.70	5.10	1.00	0.85	**Unsatisfactory**

The total area of the envelope structure is 957.70 m^2. The heat transfer coefficient of the envelope structure, including the specific heat loss due to thermal bridges, is 1,352.80 W.K-1. The specific heat loss due to thermal bridges is 95.80 W.K-1. According to STN 73 0540-2, meeting of the minimum requirement for the average heat transfer coefficient of the total envelope structures of the building is shown in the table.

Table 10 Average heat transfer coefficient of the building

Building form factor	Average heat transfer coefficient	Normalised value	Recommended value	Target recommended value	Assessment according to STN 73 0540-2
	U_{priem}	U_N	U_{r1}	$U_{r2,\,Cieľ}$	
	$(W.m^{-2}.K^{-1})$	$(W.m^{-2}.K^{-1})$	$(W.m^{-2}.K^{-1})$	$(W.m^{-2}.K^{-1})$	
0.85	1.413	0.41	0.29	0.29	**Unsatisfactory**

Heat demand for heating

The calculation of the heat demand for heating was made on the basis of the calculation of the heat loss due to heat transfer within structural elements and due to ventilation, which was reduced by heat gains. The total annual heat demand to cover heat loss due to transfer and ventilation is 99,442.83 kWh.

Table 11 Heat demand for heating and corresponding calculation results

Specific heat loss due to thermal bridges	(W/K)	ΔH_{TM}	95.76
Specific heat loss heat loss between the heated space without thermal bridges	(W/K)	H_u	1,257.04
Specific heat loss due to transfer	(W/K)	$H_T = Hu + \Delta H_{TM}$	1,352.80
Minimum air exchange rate	(l/h)	n_{min}	0.50
Air exchange intensity due to infiltration	(l/h)	n	0.43
Average air exchange intensity	(l/h)	$n = \max(n_{min}; n_{inf})$	0,50
Volume flow rate of the mechanical ventilation system	(m^3/h)	V_f	0.00
Volumetric air flow rate	(m^3/h)	V_v	897.27
Specific ventilation heat loss	(W/K)	$H_V = 0.264 . V_V$	148.05
Specific heat loss	(W/K)	$H = H_T + H_V$	1,500.85
Internal heat gain	(kWh)	Q_I	9,130.62
Passive solar gain	(kWh)	Q_S	3,690.29
Total heat gain of the building	(kWh)	$Q_g = Q_i + Q_s$	12,820.91
Heat gain utilisation factor		η	0.97
Heat demand to cover heat losses through transition	(kWh)	Q_T	**100,761.97**
Heat demand to cover heat losses through ventilation	(kWh)	Q_v	**11,027.51**
Heat demand for heating	(kWh)	Q_h	**99,442.83**

Assessment of the building in terms of the heat demand for heating

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operating time of heating was taken into account with the determined effect on a decrease of the internal temperature in the category of buildings – an administrative building.

Table 12 Assessment of the building according to STN 73 0540-2

Building form factor	(1/m)	$\Sigma A_i/V_b$	**0.85**
CH heat demand in the reference heating season	(kWh)	Q_h	**99,442.83**
Specific heat demand for heating	(kWh/m²)	Q_{EP}	**332.48**
Normalised value	(kWh/m²)	$Q_{N,EP}$	**53.50**
Recommended value	(kWh/m²)	$Q_{r1,EP}$	**26.80**
Target recommended value	(kWh/m²)	$Q_{r2,EP}$	**13.40**
Building assessment according to STN 73 0540 - 2		$Q_{EP} \leq Q_{N,EP}$	**Unsatisfactory**

The assessed building does not meet the primary energy criterion.

Classification of the building in terms of energy consumption - current state

The current state of the building does not meet the energy criterion. In terms of heating system, hot water preparation and lighting system, the total energy requirement falls into Class **G**. In terms of primary energy consumption, the building falls into Class **B**.

PROPOSAL FOR MEASURES TOREDUCE ENERGY CONSUMPTION - BUILDING MODIFICATIONS AND THEIR ECONOMIC AND ENVIRONMENTAL ASSESSMENT

The following measures were proposed to reduce the energy demand of the building, which is the subject of the energy audit. The results of energy and economic calculations, as well as, the operational parameters of the building, its method and time of use were taken into account to design the measures. For the assessment of energy consumption reduction, the percentage rate of reduction in the energy demand of the building, determined by calculations based on the real energy consumption of the used technology, is taken into account. The monetary value of energy savings with an annual update rate of 2.5% shall be used in the calculation of the rate of return. All measures are energetically and economically assessed based on the average values of the energy and economic demands of building operation time for the years 2018-2020. The real discount rate, taking into account the annual inflation rate, was set at 3.0%. The amount of the investment costs was determined on the basis of the price lists and on the basis of the usual prices for proposed equipment and work. Thermal insulation was designed to meet the required values of heat transfer coefficients, while technical feasibility was also taken into account.

Measure 1a

The proposal is the insulation of the perimeter wall with a thermal insulator based on mineral wool 150 mm thick, the insulation of the roof structure with a mineral wool insulator 300 mm thick, the insulation of the ceiling structure to the attic with mineral wool based insulator 280 mm thick, the insulation of the floor on the ground with 100 mm thick insulator and the replacement of all infill structures with new triple glazed plastic windows and triple glazed plastic doors.

Recommendation:

- Insulation of the perimeter wall assumes an assessment of its current condition or its renovation according to the needs and recommendations of the project documentation administrator - designer.

- The insulation of the roof and ceiling structure implies an assessment of its current condition or its renovation(e.g. replacement of roofing material) according to the needs and recommendations of the project documentation administrator - the designer.

- The above thermal insulation materials are only intended as an example for easier orientation when selecting the thermal properties of the thermal insulation system.

Table 13 Calculation of heat demand for heating after the implementation of measure 1a

Specific heat loss due to thermal bridges	(W/K)	ΔH_{TM}	50.16
Specific heat loss heat loss between the heated space without thermal bridges	(W/K)	H_u	192.53
Specific heat loss due to transfer	(W/K)	$H_T = Hu + \Delta H_{TM}$	242.69
Minimum air exchange rate	(l/h)	n_{min}	0.50
Air exchange intensity due to infiltration	(l/h)	n	0.23
Average air exchange intensity	(l/h)	$n = max (n_{min}; n_{inf})$	0.50
Volume flow rate of the mechanical ventilation system	(m^3/h)	V_f	0.00
Volumetric air flow rate	(m^3/h)	V_v	942.14
Specific ventilation heat loss	(W/K)	$H_V = 0.264 . V_V$	155.45
Specific heat loss	(W/K)	$H = H_T + H_V$	398.14
Internal heat gain	(kWh)	Q_I	9,587.01
Passive solar gain	(kWh)	Q_S	2,427.83
Total heat gain of the building	(kWh)	$Q_g = Q_i + Q_s$	12,014.84
Heat gain utilisation factor		η	0.95
Heat demand to cover heat losses due to transfer	(kWh)	Q_T	**18,076.50**
Heat demand to cover ventilation heat losses	(kWh)	Q_V	**11,578.75**
Heat demand for heating	(kWh)	Q_h	**18,285.38**

Energy and economic assessment of the proposed Measure 1a

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operation time of heating was taken into account with the determined effect on a decrease of the internal temperatureduring intermittent operation in the relevant category of buildings. In order to demonstrate achieving the energy efficiency of the building, the specific heat demand for heating should be lower than the standardized value. The results of the assessment are shown in the table.

Table 14 Assessment of the building according to STN 73 0540-2 –after the implementation of measure 1a

Building form factor	(1/m)	$\Sigma A_i/V_b$	**0.85**
UK heat demand in the reference heating season	(kWh)	Q_h	**18,285.38**
Specific heat demand for heating	(kWh/m²)	Q_{EP}	**58.23**
Normalised value	(kWh/m²)	$Q_{N,EP}$	**53.50**
Recommended value	(kWh/m²)	$Q_{r1,EP}$	**26.80**
Target recommended value	(kWh/m²)	$Q_{r2,EP}$	**13.40**
Building assessment according to STN 73 0540 - 2		$Q_{EP} \leq Q_{N,EP}$	**Unsatisfactory**

By implementing construction measures it is possible to save 81.61% of energy savings in the specific heat demand for heating, which represents 81.16MWh of thermal energy.

Taking into account the actual energy consumption based on the current operation and use of the building under consideration, the implementation of building measure 1a is expected to reduce the energy consumption for heating by 62.22 MWh/year, which represents 85.03% energy savings. The assessment of the reduction in energy consumption takes into account the percentage reduction in the energy performance of the building determined by a calculation based on the actual energy consumption of the technology used so far.

The energy and economic assessment of the proposed modifications 1a is summarised in the tables:

Table 15 Energy assessment of measure 1a

Specific heat loss through transition (W.K-1)	(W/K)	**242.69**
Average air change rate (h-1)	(1/h)	**0.50**
Specific heat loss through ventilation (W.K-1)	(W/K)	**155.45**
Specific heat loss (W.K-1)	(W/K)	**398.14**
Internal heat gains (kWh/year)	(kWh/ year)	**9,587.01**

Passive solar gains (kWh/year)	(kWh/ year)	**2,427.83**
Total building heat gain (kWh/year)	(kWh/ year)	**12,014.84**
Heat demand for heating (kWh/year)	(kWh/ year)	**18,285.38**

Table 16 Economic evaluation of measure 1a

Investment cost for the implementation of the measure without VAT (€)	**107,681**
Annual energy savings (kWh/year)	**62,224.55**
Annual energy savings (%)	**85.03**
Annual energy cost savings (€)	**4,116.03**
Measure lifetime (years)	**995.34**
Simple payback period (years)	**108.19**

Measure 1b

The propposal is the insulation of the perimeter wall with a thermal insulator based on mineral wool thickness of 150 mm, the insulation of the roof structure with a mineral wool insulator thickness of 300 mm, the insulation of the ceiling structure to the attic with a mineral wool insulator thickness of 280 mm, the insulation of the floor on the ground with an insulator thickness of 280 mm, the insulation of the floor on the ground with a mineral wool insulator thickness of 300 mm, the insulation of the ceiling structure to the attic with a mineral wool insulator thickness of 280 mm, the insulation of the floor on the ground with a mineral wool insulator thickness of 300 mm. 100 mm and the replacement of all filling structures with new plastic windows with triple glazing and plastic doors with triple glazing. In addition, the installation of a local recuperation unit in individual rooms is proposed.

Recommendation:

- Insulation of the perimeter wall assumes an assessment of its current condition or its renovation according to the needs and recommendations of the project documentation administrator - designer.

- The insulation of the roof and ceiling structure implies an assessment of its current condition or its renovation(e.g. replacement of roofing material) according to the needs and recommendations of the project documentation administrator - the designer.

- The above thermal insulation materials are only intended as an example for easier orientation when selecting the thermal properties of the thermal insulation system.

Table 17 Calculation of heat demand for heating after the implementation of measure 1b

Specific heat loss due to thermal bridges	(W/K)	ΔH_{TM}	50.16
Specific heat loss heat loss between the heated space without thermal bridges	(W/K)	H_u	192.53
Specific heat loss due to transfer	(W/K)	$H_T = Hu + \Delta H_{TM}$	242.69
Minimum air exchange rate	(l/h)	n_{min}	0.50
Air exchange intensity due to infiltration	(l/h)	n	0.23
Average air exchange intensity	(l/h)	$n = \max(n_{min}; n_{inf})$	0.50
Volume flow rate of the mechanical ventilation system	(m^3/h)	V_f	614.60
Volumetric air flow rate	(m^3/h)	V_v	942.14
Specific ventilation heat loss	(W/K)	$H_V = 0.264 . V_V$	74.32
Specific heat loss	(W/K)	$H = H_T + H_V$	317.01
Internal heat gain	(kWh)	Q_I	9,587.01
Passive solar gain	(kWh)	Q_S	2,427.83
Total heat gain of the building	(kWh)	$Q_g = Q_i + Q_s$	12,014.84
Heat gain utilisation factor		η	0.94
Heat demand to cover heat losses due to transfer	(kWh)	Q_T	**18,076.54**
Heat demand to cover ventilation heat losses	(kWh)	Q_v	**5,536.03**
Heat demand for heating	(kWh)	Q_h	**12,437.37**

Energy and economic assessment of the proposed Measure 1b

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operation time of heating was taken into account with the determined effect on a decrease of the internal temperatureduring intermittent operation in the relevant category of buildings. In order to demonstrate achieving the energy efficiency of the building, the specific heat demand for heating should be lower than the standardized value. The results of the assessment are shown in the table.

Table 18 Assessment of the building according to STN 73 0540-2 – after the implementation of measure 1b

Building form factor	(1/m)	$\Sigma A_i/V_b$	**0.85**
UK heat demand in the reference heating season	(kWh)	Q_h	**12,437.37**
Specific heat demand for heating	(kWh/m²)	Q_{EP}	**39.60**
Normalised value	(kWh/m²)	$Q_{N,EP}$	**53.50**
Recommended value	(kWh/m²)	$Q_{r1,EP}$	**26.80**
Target recommended value	(kWh/m²)	$Q_{r2,EP}$	**13.40**
Building assessment according to STN 73 0540 - 2		$Q_{EP} \leq Q_{N,EP}$	**Unsatisfactory**

In comparison with the current situation, it is possible to save 87.49% of energy at the specific heat demand for heating, which is 87.01 MWh of heat energy.

Taking into account the actual energy consumption based on the current operation and use of the building under consideration, the implementation of building measure 1b is expected to reduce the energy consumption for heating by 65.73 MWh/year, which represents 89.82% energy savings. The assessment of the reduction in energy consumption takes into account the percentage reduction in the energy performance of the building determined by a calculation based on the actual energy consumption of the technology used so far.

The energy and economic assessment of the proposed modifications 1b is summarised in the tables:

Table 19 Energy assessment of measure 1b

Specific heat loss through transition (W.K-1)	(W/K)	**242.69**
Average air change rate (h-1)	(l/h)	**0.50**
Specific heat loss through ventilation (W.K-1)	(W/K)	**74.32**
Specific heat loss (W.K-1)	(W/K)	**317.01**
Internal heat gains (kWh/year)	(kWh/year)	**9,587.01**
Passive solar gains (kWh/year)	(kWh/year)	**2,427.83**
Total building heat gain (kWh/year)	(kWh/year)	**12,014.84**
Heat demand for heating (kWh/year)	(kWh/year)	**12,437.37**

Table 20 Economic evaluation of measure 1b

Investment cost for the implementation of the measure without VAT (€)	**120,181**
Annual energy savings (kWh/year)	**65,727.28**
Annual energy savings (%)	**89.82**
Annual energy cost savings (€)	**1,051.37**
Simple payback period (years)	**114.31**

7. PROPOSAL FOR MEASURES TO REDUCE ENERGY CONSUMPTION - TECHNICAL EQUIPMENT IN THE BUILDING

Measure 2: Installation of more energy efficient lighting fixtures
- replacing the original T8 fluorescent luminaires (2x36W) with classical ballasts with LED panels of 36W, incandescent luminaires with classical 60W bulbs with 1x11W, 1x15W LED bulbs

- supplying the number of luminaires to meet the requirements in terms of lighting intensity in accordance with STN EN 12 464 -1 „Lighting of workplaces, reconstruction of motor and light wiring“.

The energy and economic assessment of the proposed measure 2
By implementing the proposed technical measure, it is possible to save up to 43.59% of the consumed electricity for lighting by replacing the light sources on the lighting, which represents 2.25 MWh of electricity per year.

Lighting energy consumption – proposed state
Average building occupancy factor (Fo): 1.00
Operating hours: 7.5 hours/day, 5 days/week (1,882.5 hours/year))
Annual lighting energy consumption - calculation: 2 621.17 kWh/year
Annual energy consumption for lighting - Actual: 2 910.63 kWh/year
Annual lighting costs (price 0.245 €/kWh): **713.00 excluding VAT**

The energy and economic assessment of the proposed modifications is summarized in the table:

Table 21 Economic assessment of measure 2

Investment cost for the implementation of the measure without VAT (€)	**10,000**
Annual energy savings (kWh/year)	**2,249.37**
Annual energy savings (%)	**43.59**

Annual energy cost savings (€)	551.02
Simple payback period (years)	18.15

Measure 3:

Replacement of the heat source for heating and hot water preparation, modernisation of the distribution system.

Heating system: Heat supply for heating is provided by a boiler for lump wood and brown coal, which is located in the utility room. The heat is supplied in the form of 70/55 °C hot water from a central source in the boiler room via a steel pipe which runs freely along the wall, in the construction. Heat is transferred by radiators located under the windows. Heating elements are not equipped with thermostatic control and the heating system is not hydraulically regulated. The condition of the heating system corresponds to the period of operation.

Hot water preparation: hot water is produced by an electric storage heater. The storage tank is located in the heated space.

Replacing the original obsolete electric hot water tanks with new electric hot water tanks is proposed.

Energy and economic evaluation of the proposed technical measure

By implementing the proposed technical measure itself, it is possible to save 15.0% of heat energy on heating, which represents 14.92 MWh of heat per year. There is an estimate for a saving of the calculated heat demand for heating compared to the original one in the case of the implementation of this variant only.

If the selected measure is implemented, the above savings should be applied to the actual heat demand. Taking into account the current operation and use of the building under consideration, the implementation of technical measure 3 is expected to result in a calculated heating saving of 22.55 MWh/year, which is 30.81%.

The energy and economic assessment of the proposed modifications is summarized in the table:

Table 22 Economic assessment of measure 3

Investment cost for the implementation of the measure without VAT (€)	28 000
Annual energy savings (kWh/year)	22 548,67
Annual energy savings (%)	30.81
Annual energy cost savings (€)	360,69
Simple payback period (years)	77,63

8. A PROPOSAL FOR OTHER NECESSARY MEASURES

Hydraulic regulation of the heating system, which ensures the correct functioning of the heating system in the building during various operating conditions during the heating period. The smooth function of the entire heating system is conditioned by the application of control elements in the form of differential pressure reg. volume flow rate, thermostatic control valves on heating elements, etc.

Introduction of zone control in the building. By dividing the building under consideration into heating zones supplied by separate heating branches, it is possible to ensure thermal comfort in all heated rooms and at the same time to reduce the heat consumption for their heating by means of attenuation modes in individual zones. The implementation of zone control allows to individually regulate (control and adjust) the thermal regime in each heating zone separately based on the actual operation and user requirements.

Introduction of an intelligent measurement and control system. A smart metering system is a set of equipment consisting of a designated meter and other technical means that enables the collection, processing and transmission of measured data on the production or consumption of energy or an energy medium. It is an electronic system that is capable of measuring energy consumption and adding more information than a conventional meter, and that is capable of transmitting and receiving data using some form of electronic communication.

For transparent monitoring of energy consumption, it is recommended that energy consumption in the building and in the individual technical systems should be continuously monitored by means of installed meters, so that the savings achieved can be continuously evaluated at least once a year.

In order to evaluate the energy savings according to the savings evaluation methodology, installing the following sub-meters in addition to the standard energy consumption measurement is recommended:

- electricity consumption at the entrance to the building,
- the electricity consumption of the internal lighting system of the building,
- the consumption of heat delivered for heating
- the consumption of heat delivered in hot water

The energy assessment does not define the energy savings that will be achieved by the implementation of these measures, as they depend on the heat demand that will be achieved after the implementation of the scope of the proposed renovation measures.

Establishment of ongoing energy management, operations and maintenance.

Energy management is a tool that will enable the stable maintenance of energy at the required level. The energy management system is based on periodic energy consumption readings and records. The aim is to ensure the correct operation of technical and technological equipment for the production, distribution and consumption of heat, with a focus on reducing energy consumption.

Rapid identification of possible faults and malfunctions. Identification of the most economically, energetically and environmentally advantageous solutions with high energy efficiency, e.g. bringing the combustion process as close as possible to the conditions necessary for the most efficient use of energy, reducing electricity consumption, etc.

9. RECOMMENDATION OF THE OPTIMAL SOLUTION - PACKAGE OF MEASURES

From the proposed measures, the overall recommended measure for the project is compiled in order to reduce the energy consumption of the administrative building in the village of Nová Bašta. This measure is recommended on the basis of an assessment of the current condition of the building and its energy needs, based on calculations, legislative and normative criteria as well as consultations with the investor. Within this summary measure it is proposed:

A combination of the above measures, i.e. a complex renovation of the building according to measure 1, replacement of the lighting system and subsequent replacement of the heat source for heating and hot water preparation, modernisation of the distribution system. As it can be seen from the calculations, the combination of measures 1 - 3 is the most financially, energetically and environmentally advantageous; the technical variants are justified in terms of reducing the energy consumption of the building under consideration.

The proposed measures should not be implemented in the form of a Guaranteed Energy Service (GES).

Table 23 Energy economic summary of the proposed measures

Recommended measure	Savings on energy (kWh/rok)	Savings on energy costs (€/year)	Investment costs excluding VAT (€)
№. 1 Complex renovation of the building's outer shell with the replacement of window openings and insulation of the roof + installation of recuperation	65,727	1,051	120,181
№ 2 Installing more energy efficient lighting fixtures	2,249	551	10,000
№ 3 Replacement of the heat source for heating and hot water preparation, modernisation of the distribution system - energy saving is included in measure 1	22,549	361	28,000
TOTAL	**67,977**	**1,602**	**158,181**

Table 24 Results of the economic assessment of the proposed measure

Investment cost for the implementation of the measure without VAT (€)	**158,181.20**
Annual energy savings (kWh/year)	**67,976.65**
Annual energy savings (%)	**86.77**
Annual energy cost savings (€)	**1,602.38**
Simple payback period (years)	**98.72**

10. ENERGY ASSESSMENT OF THE BUILDING

For the assessment of the building in terms of meeting the minimum requirement for the energy efficiency of the building according to STN 73 0540-2, the climatic data of the reference heating season were used. In addition, the operating time of heating was taken into account with the determined effect on a decrease of the internal temperature in the category of buildings – an administrative building. To meet the energy criterion, the specific heat demand for heating must be less than the standardized value.

Table 25 Assessment of the building according to STN 73 0540-2

Building form factor	(1/m)	$\Sigma A_i/V_b$	**0.85**
CH heat demand in the reference heating season	(kWh)	Q_h	**12,437.37**
Specific heat demand for heating	(kWh/m²)	Q_{EP}	**39.60**
Normalised value	(kWh/m²)	$Q_{N,EP}$	**53.50**
Recommended value	(kWh/m²)	$Q_{r1,EP}$	**26.80**
Target recommended value	(kWh/m²)	$Q_{r2,EP}$	**13.40**
Building assessment according to STN 73 0540 - 2		$Q_{EP} \leq Q_{N,EP}$	**Unsatisfactory**

The assessed building does not meet the energy criterion.

Based on the conclusions of the energy audit, it is recommended to implement the resulting measure due to the energy and economic savings in operating costs, despite the fact that the building does not meet the energy performance in terms of heat demand for heating according to STN 73 0540-2+Z1+Z2:2019. Further construction measures would be inefficient and technically, functionally and economically unfeasible.

Building energy classification - proposed state

The building falls into category B in terms of total energy demand and A1 in terms of primary energy consumption.

The assessed building does not meet the primary energy requirement.

11. ENVIRONMENTAL ASSESSMENT

Enviromental assessment was done by calculating the differences in primary energy inputs in MWh before and after the measures and their multiplying by the emission coeficients of the individual relevant pollutants. The following tables provide an environmental assessment of the complex measure.

Table 26Energy in the primary carrier

Indicator	The present			After measures			Change %
	from GAS	from electricity	together	from GAS	from electricity	together	
Energy Mwh	73.18	5.16	78.34	7.45	2.91	10.36	-86.8

Table 27 Emissions of pollutants for the complex measure

Indicator	The present			After measures			Change %
	from GAS	from electricity	together	from GAS	from electricity	together	
CO_2 t/r	12.55	1.81	4.36	1.34	1.02	2.36	-83.6
CO kg/r	0.87	2.32	3.19	0.46	1.31	1.77	-44.7
TZL kg/r	16.43	0.92	17.35	0.21	0.52	0.72	-95.8
SO_2 kg/r	121.39	4.59	125.98	0.00	2.59	2.59	-97.9
NO_x kg/r	81.07	5.05	86.11	2.47	2.85	5.32	-93.8
PM2,5 kg/r	4.93	0.28	5.20	0.06	0.16	0.22	-95.8
PM 10 kg/r	11.50	0.64	12.14	0.14	0.36	0.51	-95.8

The project of the intended insulation of the building structures of the administrative building in the village of Nová Bašta, replacement of windows and doors in transparent openings, replacement of the lighting system is a significant local environmental benefit.

All monitored air pollutant emissions shall lower significantly in the future from 44.7% to 97.9% in the future.

12. CONCLUSION

The aim of the energy audit is to point out the potential of energy savings in the assessed buildings, taking into account local, technical and economic factors. The auditor must also take into account the requirements of the investor.

When deciding on the advantages or disadvantages of a project, there are several factors that need to be focused on individually. On the one hand, there is the economics of the project and the return on investment, on the other hand, there is an effort to reduce the energy demand for providing thermal comfort. At present, a significant factor is the impact on the environment and the reduction of greenhouse gas production, in particular CO2. However, the economic return is sometimes in the last place when considering buildings with specific use where the operator's primary goal should be providing thermal comfort and comfort of using the building with the lowest possible operating costs.

All calculations, conclusions and recommendations are based on the assessment of energy consumption in the years 2018-2020. The level of investment costs and economic assestment were determined on the basis of price lists and qualified financial estimates.

13. DATA FILE FOR MONITORING SYSTEM

Energy audit of the administrative building in the village of Nová Bašta	
Classification according to SK NACE (according to the main activity of the client of the energy audit)	84110
Total energy savings potential (Mwh)	67.98
A SET OF PROPOSED MEASURES TO REDUCE ENERGY CONSUMPTION	
Brief description of the proposed measures	Insulation of the facade with insulator - thickness 150 mm, insulation of the ceiling structure with insulator - thickness 280 mm, insulation of the flat roof with insulator - thickness 300 mm, insulation of the floor with insulator - thickness 100 mm and replacement of all the opening structures with a new plastic window with triple insulating glazing and a plastic door with triple insulating glazing. The installation of a heat recovery unit for air exchange. Replacement of the lighting system and subsequent modernisation of the heat preparation and distribution system for heating and hot water.
Costs of technologies for energy conversion and distribution (in thousands of €)	38.00
Costs of production technologies (in thousands of €)	0.00
Costs for reducing the energy efficiency of buildings (in thousands of €)	120.18
Other costs (in thousands of €)	
Total costs for implementing the proposed measures (in thousands of €)	158.18

SUMMARY BALANCE DATA

	Before implementing the measures	After implementing the measures	Difference
Energy consumption (MWh/yr)	78.34	10.36	-67.98
Energy costs in current prices (in thousands of €)	2.43	0.83	-1.60

BENEFITS IN TERMS OF ENVIRONMENTAL PROTECTION

Pollutant/greenhouse gas	Before implementing the measures	After implementing the measures	Difference
Solid pollutants (t/r)	0.017	0.001	-0.017
SO_x (t/r)	0.126	0.0026	-0.123
CO (t/r)	0.086	0.005	-0.081
CO_2 (t/r)	0.0032	0.0018	-0.0014
	14.357	2.360	-11.998

ECONOMIC ASSESSMENT

Cash-flow of the project (in thousands of €/year)	–	Assessement period (years)	–
		Discount rate (%)	–
Simple payback period (years)	98.7	NPV (in thousands of €)	–
Realpayback period (years)	–	IRR (%)	–
Energy auditor		Ing. Martin Štefanco, PhD.	
Signature		The date	September 2021

Annex 1 - photo documentation

Figure 13 Views of building

Figure 14 Heating system and hot water preparation

7. ENERGY EFFICIENCY LABORATORIES CREATED IN THE FRAMEWORK OF THE "NESICA" PROJECT

7.1 ENERGY LABORATORY FOR COMMUNITIES – UKRAINE

In Uzhhorod, within the framework of the project, the Energy efficiency laboratory for communities "NESiCA" was created. The aim of the laboratory is to provide services for determining the sources and amount of inefficient use of fuel energy resources, hot and cold water, electricity and thermal energy, identifying the potential for energy saving and developing effective measures aimed at increasing the energy efficiency of a complex of buildings, including technical and economic assessment and impact on the environment at communal and private property in Zakarpattia region and beyond.

The main tasks of the Energy efficiency laboratory for communities "NESiCA":

- technical and economic analysis of the efficiency of use and losses of fuel energy resources, hot and cold water, electricity and thermal energy, development and description of energy efficiency measures necessary for implementation;
- providing recommendations regarding the priority of implementing energy-saving measures, considering their cost and profitability;
- determination of prospects and possibilities of using alternative energy sources to further increase the energy efficiency of the of building complexes;
- compilation of energy passports for buildings, energy efficiency certificates and energy audit reports;
- further support and determination of the possibility of attracting investment resources;
- improvement of the information support system for the provision of energy efficiency services;
- promoting the creation of a new generation of specialists in the relevant field, cross-border cooperation and European integration, with the involvement of international experts, exchange of experience, issue of joint information publications;
- European methods and standards usage and the formation of a stable level of cooperation between Ukrainian and European energy efficiency institutions.

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7.2 ENERGY LABORATORY FOR COMMUNITIES – HUNGARY

University of Nyíregyháza, Szabolcs-Szatmár Bereg County

The Energy Laboratory for Communities (ELC) was established at the University of Nyíregyháza, which is the result of the implementation of the cross-border project New Energy Solutions in the Carpathian Area - NESICA. The Energy Laboratory for Communities of Szabolcs-Szatmár-Bereg county carries out its activity within the Institute of Engineering and Agriculture in University of Nyíregyháza. The main goal of the laboratory is to promote energy efficiency and energy awareness and help in designing of renewable energy sources for the communities of the county, mainly through education and R&D activities.

The laboratory will help communities in the county to plan for the use of renewable energy sources and determine the energy consumption and energy losses of existing buildings. The experts of ELC will provide design and consultancy services to the representatives of the communities of Szablocs-Szatmár-Bereg county regarding the implementation of renewable energy sources and best practices. The energy laboratory is equipped with modern specialized equipment for the fulfillment of its main goals.

Building C at the University of Nyíregyháza, where the laboratory is located

One of the installed meteorological measuring stations

The project included the purchase of 2 meteorological measuring stations. These measuring stations will support further research work on renewable energies. The two monitoring stations are located at two different sites: one on the campus of the University and the other on the training farm 10 km from the University. The meteorological measuring stations measure and record the most important meteorological data, as well as wind direction, wind gusts, solar radiation and soil moisture. Additional specialised equipment is available in the laboratory: **FLUKE Ti32 IR Fusion Technology, VarioCam High Definition Thermal Camera.**

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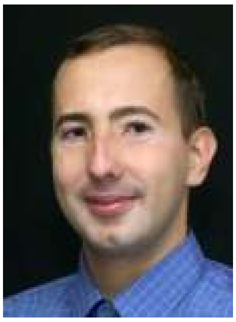

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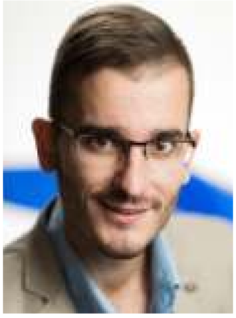

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Data provided by the meteorological stations of the laboratory

FLUKE Ti32 IR Fusion Technology

Vario Cam High Definition Thermal Camera

7.3 ENERGY LABORATORY FOR COMMUNITIES – ROMANIA

Stefan cel Mare University of Suceava

The Energy Laboratory for Communities (ELC) was established at the Stefan cel Mare University of Suceava, which is the result of the implementation of the cross-border project New Energy Solutions in the Carpathian Area - NESICA. The Energy Laboratory for Communities carries out its activity within the Faculty of Electrical Engineering and Computer Science and its main goal is to promote the concept of energy efficiency and renewable energy sources for the communities of Suceava county, through education and practical activities. This laboratory will offer, among other things, solutions for monitoring and measuring the parameters of electricity produced through renewable energy sources. The experts, members of ELC, will provide to the representatives of the communities from the North-East of Romania, design and consultancy services regarding the implementation of renewable energy sources as well as examples of good practice. LEC's expert team, established of teaching staff with outstanding results and extensive experience in the field of energy efficiency, has the ability to identify the bestthermal energy rehabilitation solutions for buildings and to issue energy performance certificates.

The energy laboratory is equipped with modern specialized equipment for carrying out specific measurements necessary for the preparation of energy audits and energy performance certificates, aiming at the identification and evaluation of the main energy characteristics of a building, after which solutions are offered for rehabilitation and modernization. The main specialized equipment: Solar-300N energy quality analyzer, Fluke Ti 401-Pro thermal imaging camera, professional stands for the study of autonomous and grid-connected photovoltaic and wind systems.

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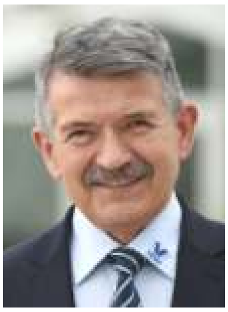

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Energy Laboratory for Communities
Equipment for the study of the operation of photovoltaic and wind systems

Power Quality Analyzer for checking the efficiency of photovoltaic systems - SOLAR 300N HT Instruments

Thermal Camera FLUKE TI401-PRO 9HZ

7.4 ENERGY LABORATORY FOR COMMUNITIES – SLOVAKIA

7.4.1 Vukonze laboratory

ENERGY ACCUMULATION – NESICA PROJECT

As part of the NESICA (New Energy Solutions in Carpathian Area) project, equipment related to the energy storage system (accumulators and related software, modular measurement system, software, control unit and communication interface) were financed at the Technical University in Košice. Facilities related to the VUKONZE research center were financed by the Faculty of Civil Engineering, and facilities related to the laboratory – SmartIndustryLab – were financed by the Faculty of Electrical Engineering and Informatics.

VUKONZE

The Center for Research on the Efficiency of Integration of Combined Systems of Renewable Energy Sources – VUKONZE will enable the creation of a research and development environment with a relevant critical concentration of research capacities necessary for the comprehensive solution of research and development problems required by practice, or by the public in the field of multivalent renewable energy sources. All sources listed on diagram Fig. 2. they are plugged into a functional system and are examined in operational states.

Fig. 1: Research Center – Center for Technological Innovations, Faculty of civil engineering, Košice

In the research center that was built, it is possible to carry out research and testing of a solar hot water system with long-term accumulation of heat in water reservoirs. The laboratories of the Faculty of Civil Engineering and the Technical University in Košice were used here.

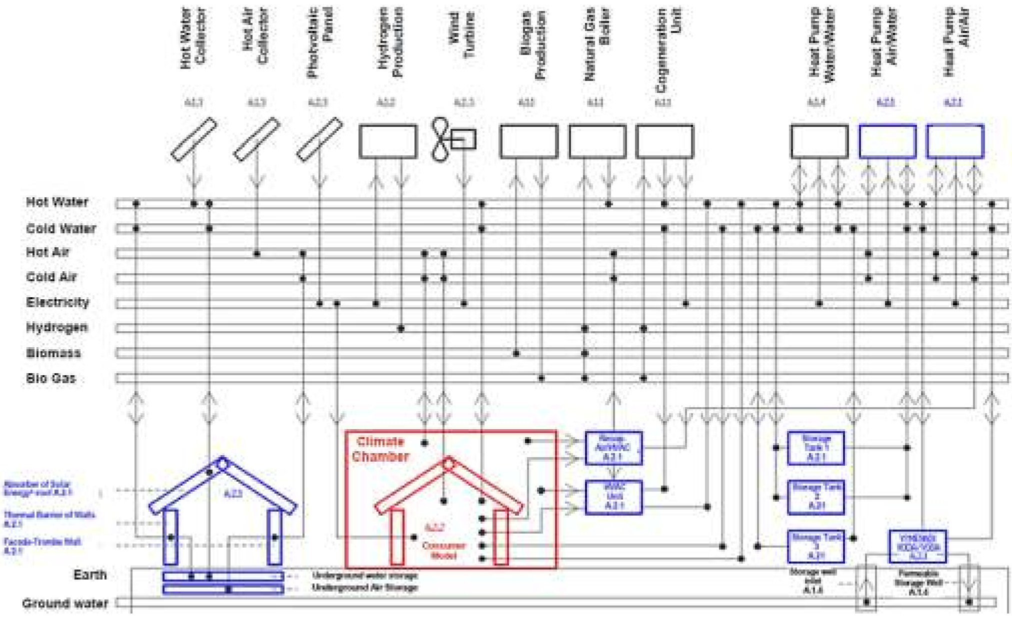


Fig. 2: Research center – energy scheme of laboratories

A climate chamber (**A**) is built in the hall and an intelligent house is built in it, under which water tanks (**C**) are built for heat accumulation. Thermal energy produced during the operation of various renewable sources (**B**) (**solar hot water collectors**) is stored in the accumulator for further use. The air-conditioned chamber makes it possible to simulate the temperature and speed of air flow around the smart house. The smart house, together with the hall where the laboratory is located, are consumers of energy obtained and stored from solar hot water panels.

*Fig. 3: Research center – solar collectors (**B**) on the roof of the laboratory*

*Fig. 4: Accumulation tanks (**C**) – construction*

*Fig. 5: Smart house (**A**) in the chamber*

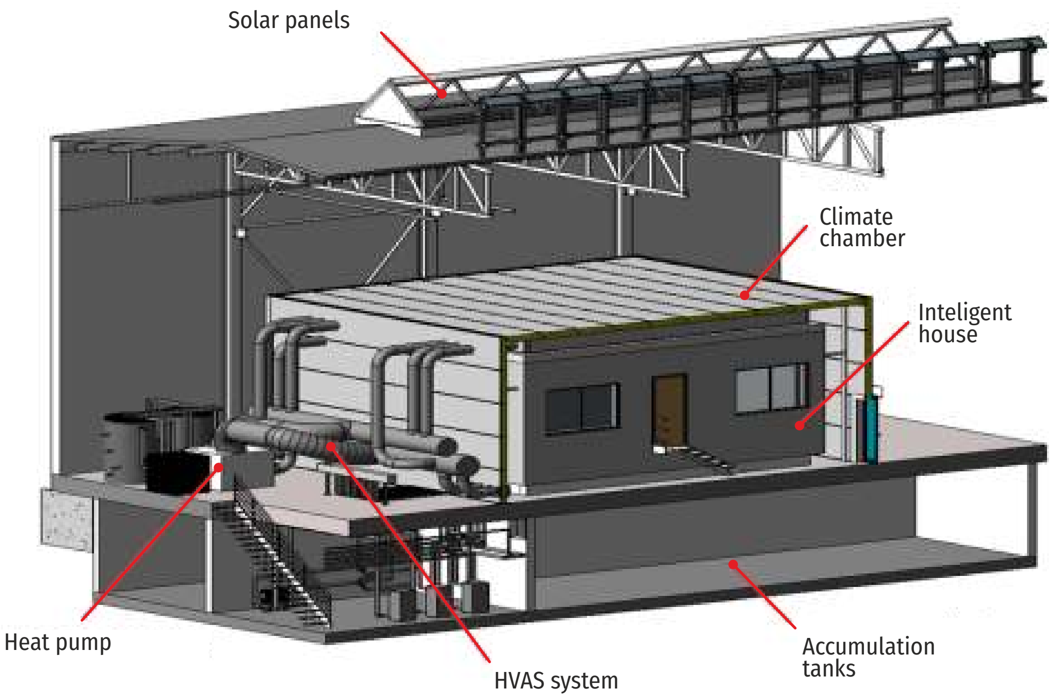


Fig. 6: 3D visualization of the system of production, accumulation and consumption of heat from solar panels

The system with long-term heat accumulation consists of solar thermal collectors with an area of 250 m^2 and three underground water reservoirs with a total volume of 160 m^3 of water. In the research center, measurements are carried out in different charging modes, temperature conditions in conjunction with heat removal into the heating system. The outputs from the measured data can be used in the creation of simulation programs. Heat pumps of various types, ventilation units and air conditioning equipment are also installed in the center. These devices work together to use the heat accumulated in the reservoirs.

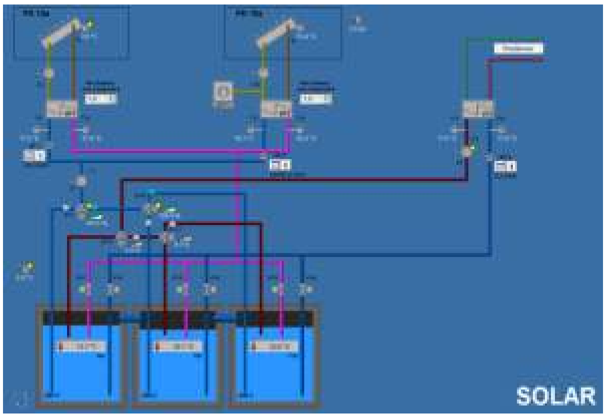


Fig. 6: System operation control scheme

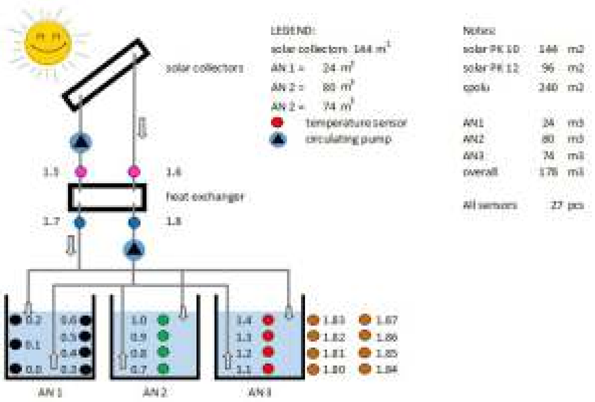
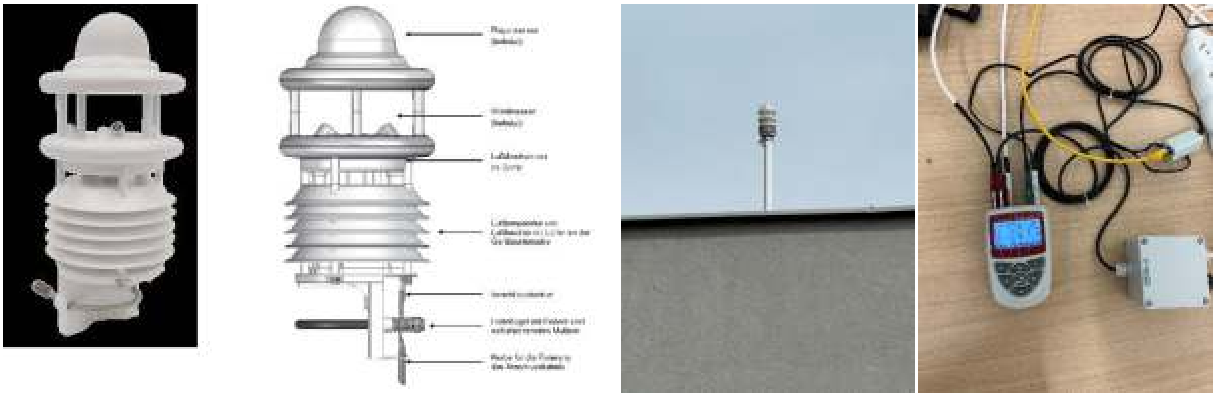


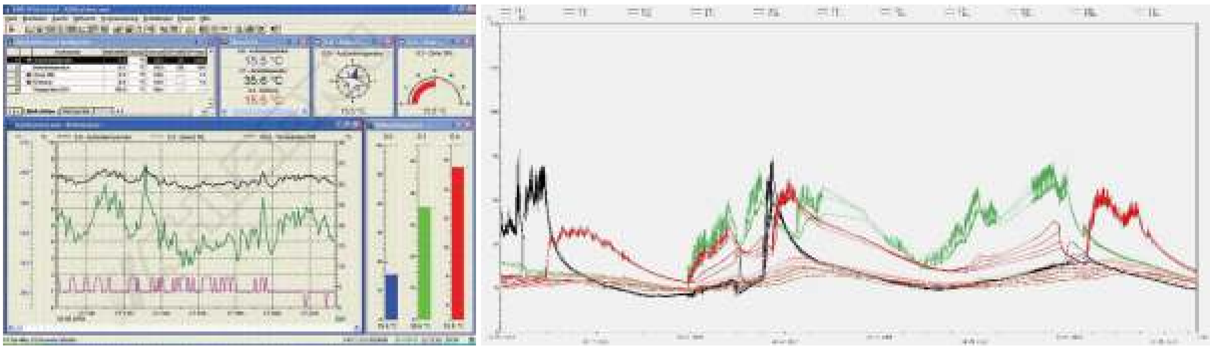
Fig. 7: System parameters measurement scheme

In order to measure operating parameters, the system was supplemented with NESiCA devices according to Fig. 7. List of equipment delivered from the NESiCA project:



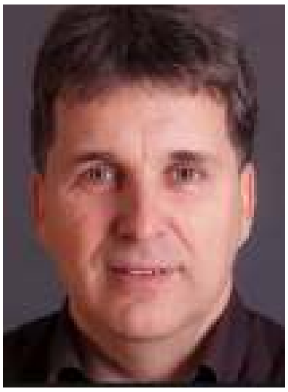
1. Weather station for recording parameters of the external environment and solar radiation.

2. Measuring station for measuring the temperature of water and the surrounding soil.



3. Software for collecting and evaluating measured data (ALMEMO AMR WINCONTROL).

The purpose is to determine the progress and efficiency of the production, accumulation and distribution of energy from solar collectors. In the reservoirs, the processes of stratification of warm water, processes of cooling and leakage of energy into the surrounding environment and through the surface of the sunken and exposed surface can be detected. Based on the measurements, there are used neural networks to construct a computational model of the system's behavior and the possibility of using energy from long-term heat accumulation.



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7.4.2 SmartIndustry Lab Laboratory

Introduction

The Technical University of Košice (TUKE) has a new energy-intelligent laboratory - Smart IndustryLab, which models a low-voltage distribution system. It was put into operation by the company Východoslovenská distribučná (VSD) in cooperation with the Technical University in Košice in 2018. The laboratory, which is located on the premises of the Department of Electrical Power Engineering, is a continuation of the already existing Hybrid Lab laboratory. It simulates conditions in a smart home and is used to test hybrid photovoltaic systems. The mutual technological connections of these laboratories enable the analysis of the impacts of new household technologies on the distribution system. Within the project **NESiCA**, there were implemented battery storage system and related equipment and software that can control accumulation of energy from renewable energy sources into batteries.

What is the laboratory for?

SmartIndustryLab is used for educational, experimental and research purposes. There is possible to model a low voltage system to which the largest number of customers is connected to the distribution system. It is also used to test the feedback effects of devices that are connected to the distribution system either by the operator itself or its customers, both customers and manufacturers, or a combination of them; with Smart Industry Lab allowing to examine their impact on the system and at the same time purpose to use different measuring systems and analyzers.

Possibilities of the laboratory

Above all, the laboratory makes it possible to model low-voltage power lines of various lengths, from 60 meters up to 3,500 meters. It is then possible to connect various devices to this line at predetermined points. These devices can either positively or negatively affect the simulated line, i.e. the distribution system model. Such devices are, for example, various types of sources of electricity generation, appliances and energy storage systems, control electronics and others. Laboratory has a high level of automation – It is equipped with a control system that allows changing, for example, input values of voltage, frequency, parameters of the modeled distribution system, parameters of sources, electricity appliances and also the place of their connection to the system.

The laboratory is equipped with special software, which can be used to specify the impact of customers on the distribution system. For example, the extent to which these appliances affect the quality of electricity. The Smart Industry Lab also includes chargers of electric cars that are located in the Department of Electrical Power Engineering close to car park outdoors, to get acquainted with the topic of e-mobility. Within the project **NESiCA**, the laboratory was supplemented with the storage batteries and related soft, namely: battery pack (based on saltwater energy storage system), MPPT solar charge controller, hybrid converter/charger, energy management system and cabling for connection to an existing laboratory with existing equipment

Two in one

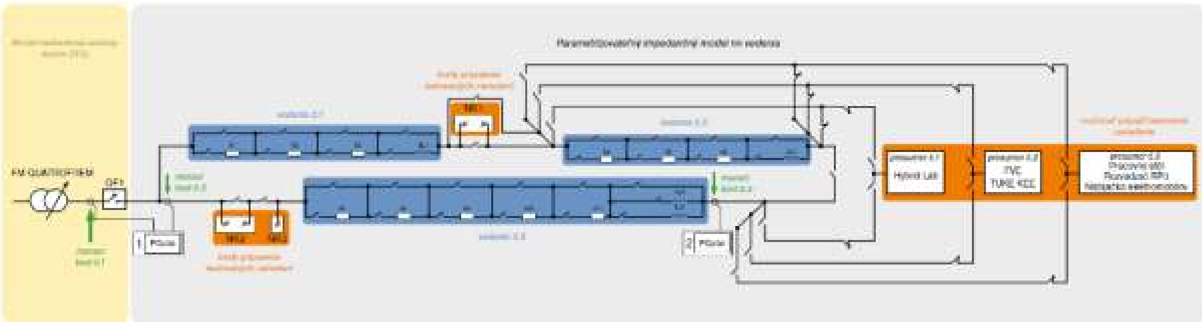
Another possibility is the interconnection of the Smar tIndustry Lab and the Hybrid Lab laboratory, as both laboratories are operated on the premises of the Technical University in Košice. By connecting the laboratories, we get a more precise model of the real situation in the system. Seemingly the same customers may have different effects on the distribution system, given the different places where they connect to it. The interoperability of laboratories expands the possibilities of testing resources.

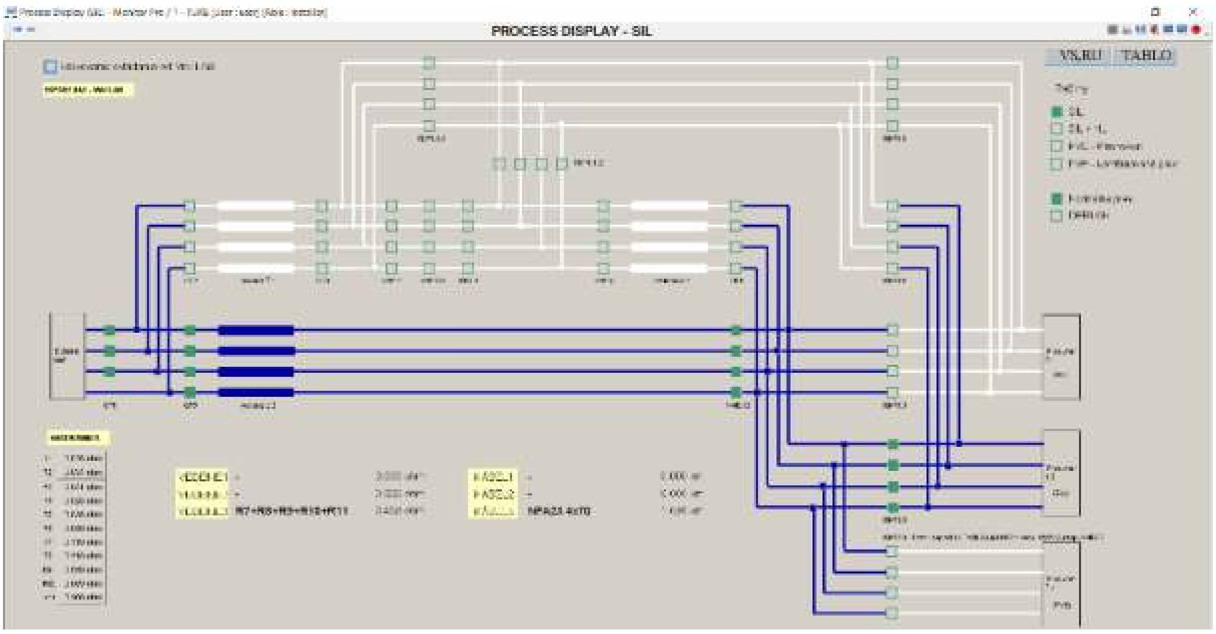
Measuring the impact of electromobility

Since the launch of the Smart Industry Lab, the Technical University of Košice has carried out several measurements at the electric vehicle charging station, which is an integral part of the laboratory. After the analysis of the measurement results, it is clear that by charging electric cars, especially of the lower middle class, the load of the distribution system is quite asymmetric. This may in some places in the distribution system in the future lead to exceeding the permitted values of the quality of electricity supplied to customers. The negative effect of an asymmetric load on the distribution system is much more intense than the effect of a symmetrical load. Basically, if the charging of electric cars were exclusively symmetrical, it would be possible to connect five times more charging stations of the same power to the system.

Lab photos:


Basic 3-ph on-grid system
PLC and sockets for appliance connection
DC source
Electricity meters Quality measurement
DC
AC
Capacitive load
Batteries 4x100 Ah
Frequency converter Isolating transformer




PROCESS DISPLAY - SIL
TABLO

Virtual tour of the laboratory: https://my.matterport.com

Within the project NESiCA, the laboratory Smart Industry Lab was supplemented with the following devices for accumulation of electrical energy:

1. Salt-water batteries (5 kWh)



2. MPPT, inverters, and regulator unit



3. Control system, protection system, battery management system (BMS)

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8. INTERVENTIONS AND CONCLUSIONS

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Lead partner: Uzhhorod National University (Ukraine)

Partners:
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- Ştefan cel Mare University of Suceava (Romania)
- NGO European Initiatives Centre (Ukraine)
- Technical University of Košice (Slovakia)
- University of Nyíregyháza (Hungary)

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The Hungary-Slovakia-Romania-Ukraine
ENI CBC Programme 2014-2020
provides EU funding for sustainable development along
the border of Ukraine with Hungary, Slovakia and Romania,
helps reducing differences in living standards and addressing
common challenges across these border

The Member States of the European Union have decided to link together their know-how, resources and destinies. Together, they have built a zone of stability, democracy and sustainable development whilst maintaining cultural diversity, tolerance and individual freedoms. The European Union is committed to sharing its achievements and its values with countries and peoples beyond its borders

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