JOINT OPERATIONAL PROGRAMME ROMANIA-UKRAINE 2014-2020
PROJECT "CROSS-BORDER COOPERATION SMART ENERGY" 2SOFT/1.2/52

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# CONTENT

## INTRODUCTION

It is generally accepted today that most of humanity's problems can be solved in the future if the main issue on the globe is solved - energy. The solution to this global problem is closely linked to preserving living space worldwide, comfortable for future generations. Ultimately, this requires the establishment of harmony between the development of all humanity and the dynamics of changes in the environment and living conditions of the population of all countries. Today, the critical aspect of solving such large-scale global problems is energy saving. In this regard, energy-saving is becoming one of the main priorities of economic policy of most countries, including Ukraine.

The UN Declaration on the Human Environment states: 'The non-renewable resources of the earth must be employed in such a way as to guard against the danger of their future exhaustion and to ensure that all mankind shares benefits from such employment.'

Thus, in our time, efficient energy use and the state of the environment are essential factors for sustainable development both at the global level and at the level of individual countries. Therefore, the combination of energy conservation and environmental protection is becoming an integral part of the sustainable development of society at the local, national, subregional, and global levels. And from the point of view of energy, there are two main areas: a significant increase in the efficiency of existing energy sources and the intensive introduction of renewable and environmentally friendly energy resources.

The importance and urgency of the rational use of energy resources must be realized today by all - both at the level of world politics and every inhabitant of the Earth. The starting point for the active participation of our state in this process was the Law of Ukraine 'On Energy Conservation,' adopted in 1994. This Law defines the legal, economic, social, and environmental bases of energy-saving for

all enterprises, associations, and organizations located on the territory of Ukraine, as well as for all its citizens.

The main burden of solving the problems outlined above will 'fall on the shoulders' of those generations today just entering adulthood, studying in schools, colleges, and universities. And young people should clearly understand that energy-saving today determines their comfortable life in the future. That energy saving is connected with all spheres of life for each of us without exception.

## PROJECT ‘CROSS-BORDER COOPERATION SMART ENERGY’

In recent years, Uzhhorod National University (Uzhhorod National University) has been implementing several international projects aimed at energy saving in the Carpathian region. One of them is the project ‘Cross-Boarder Cooperation Smart Energy‘ 2SOFT/1.2/52 (hereinafter the project CBCSmartEnergy). It is implemented within the framework of the Joint Cross-Border Cooperation Program ‘Romania-Ukraine 2014-2020’ by three partners: "Stefan cel Mare" University of Suceava, Romania, SU ‘Uzhhorod National University’, Ukraine, and the International Association of Regional Development Institutions, Ukraine.

Today, the border areas of Romania and Ukraine form a single and compact border region. Its unity is due to a similar economic structure, the nature of foreign economic relations, the structure of human resources, and standard natural systems.

Each local community in the region is trying to offer new technologies and innovations to solve the problems of efficient energy consumption and energy-saving, trying to reduce energy consumption by residential and municipal buildings and the associated economic costs. The newly formed communities also have significant needs for the development of education, research, and technology in energy-saving and the use of new renewable energy sources. As a result, energy efficiency is becoming a fundamental issue in the life of local communities in the cross-border region of Ukraine - Romania, and all other communities in our countries. Therefore, the CBCSmartEnergy project aims at:

- creation of a robust information and communication platform, which should serve the development of educational programs at UzhNU, providing researchers and young innovators with skills and knowledge on energy conservation and development of renewable energy;

- introduction of common strategic approaches and harmonization of energy-saving measures on both sides of the border;

- development of the Smart Energy Concept of Cross-Border Cooperation in the Border Regions of Romania and Ukraine;

- solving energy problems by local communities at the local level using the most efficient of the existing natural resources in the cross-border region;

- increasing the level of use of new technologies and innovations in the field of renewable energy by territorial communities;

- creation of energy laboratories of the communities of Suceava and Uzhhorod with the purchase of modern equipment by the project executors for researching the field of renewable energy and energy efficiency and for conducting energy audits of various objects of territorial communities;

- promoting the exchange of experiences and best practices between partners and local communities on regional sustainable energy strategies, awareness and education policies, activities and projects implemented in different communities in the region;

- introduction of a curriculum at Uzhhorod National University for the training of energy management specialists;

- conducting energy audits and modernization of lighting systems in several buildings of the project partners and pilot new territorial communities of the cross-border region;

- conducting scientific and practical seminars, round tables, and training on energy efficiency and renewable energy.

As you can see, the CBCSmartEnergy project is unique in that it combines educational, scientific, and institutional components. The educational part is provided by gradual introduction for students of natural faculties of UzhNU of a training course 'Fundamentals of energy audit and energetic management'. Thus, many Uzhhorod National University graduates will have basic professional training in conducting energy audits and energy management activities. The

basis of the scientific component of the project involves teachers and students of the Faculty of Engineering and Technology of various studies on the application of best practices in the use of modern alternative energy sources and effective solutions for energy management in the territorial communities. The institutional component of the project is to create an international information center for energy management at the Faculty of Engineering. In addition, a modern energy-efficient smart lighting system will be installed in the Faculty of Chemistry and Biological Faculty of Uzhhorod National University buildings, and all main facilities of Uzhhorod National University will be equipped with 'smart' electricity meters.

Implementation of the international project CBCSmartEnergy is a matter that requires responsibility, and however, it also provides significant additional opportunities for the university's development. The international grant won by Uzhhorod National University is an important indicator of the trust of the international community and the university's authority in scientific circles. But thanks to the implementation of the project through the practical, scientific and educational components, there is also a wide popularization of environmental protection in Zakarpattia through energy efficiency and energy conservation in its local communities. Within the framework of such popularization, we will get acquainted with the critical basic terms of energy-saving and the energy causes and consequences of the ecological crisis in the world and Ukraine.

## NOMENCLATURE OF ENERGY-SAVING AND ENERGY AUDIT

Every educated person should understand the modern 'language' of energy saving. Its 'alphabet' consists of the basic concepts set out in the 'Law on Energy Conservation':

- energy saving - any activity aimed at the rational use of energy resources and economical consumption of primary and transformed energy in the national economy;
- energy saving policy - administrative, legal, financial, and economic regulation of the processes of extraction, processing, transportation, storage, production, distribution, and use of energy resources for their rational and economical use;
- energy resources - a set of all types of fuel and energy used in the national economy;
- primary types of energy - those forms of energy in nature that have not been converted by various technical processes (fossil fuels, solar energy, etc.);
- types of converted energy - all types of energy that were obtained as a result of the processing of primary energy (for example, thermal energy, electric energy);
- secondary energy resources - energy potential of products, waste, by-products, and intermediate products, which is formed in technological processes and is not used in the unit itself, but maybe partially or wholly used for power supply of other processes;
- unconventional and renewable energy sources - sources that constantly exist or periodically appear in the environment in the form of energy flows of the Sun, wind, the heat of the Earth, the power of the seas, oceans, rivers, biomass;
- rational use of energy resources - achieving maximum energy efficiency from all available energy resources at the current level of development of machinery and technology while reducing the man-made impact of human activities on the environment;

- energy audit - determining the efficiency of energy resources and developing recommendations for its improvement;

- energy saving measures - any measures aimed at implementing such conditions, technologies, products, and equipment that reduce energy losses;

- energy saving management - a management system aimed at ensuring the rational use of energy resources by consumers;

## WORLD ENERGY CONSUMPTION AND ITS CONSEQUENCES

A characteristic feature of the technical activity of humanity in the second half of the XX and early XXI centuries is the rapid growth of energy consumption. Today, the world's annual energy consumption is approaching 20 TW (20,000,000,000,000,000 W!). Scientists estimate that humanity's energy needs in the XXIst century will double every 20 to 30 years. Such trends in world development are closely linked to many socio-economic causes and consequences:

- rapid growth of the world economy as a whole (according to forecasts up to 4 times by 2050);
- sharp economic growth of developing countries (China, India, part of Africa);
- significant population growth on the planet (according to forecasts to 10 - 11 billion by 2050);
- impossibility to satisfy soon further growth of world energy consumption only through the use of fossil energy sources;
- most types of fossil fuels, the deposits of which are quite large, do not meet modern environmental requirements;
- 'clean' ways of using fossil fuels leads to a significant increase in energy prices;
- development of nuclear energy is undesirable due to the high risk of man-made disasters and severe problems with the disposal of radioactive waste;
- thermal pollution of the Earth, which lead to irreversible changes in the world climate;

Environmental pollution of the Earth can already be considered a crisis due to the high concentration of nitrogen and sulfur oxides, carbon dioxide, dust particles, radioactive isotopes, etc., in the air. In fig. 1 shows the nature of changes in world energy production from different resource sources. The figure shows that in the world by 2035 is expected to significantly reduce oil use and increase the contribution to the energy sector of nuclear energy and

renewable energy sources. Consumption of other energy resources remains approximately the same.

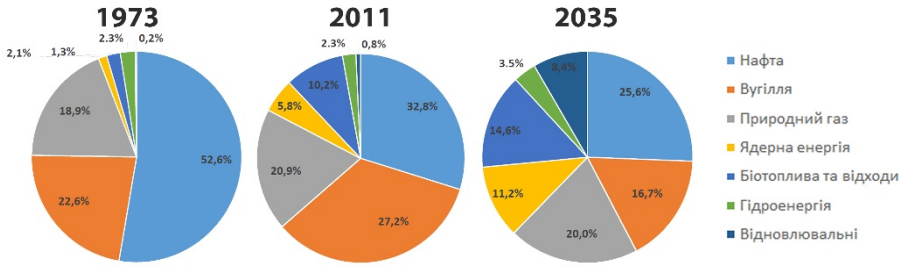


***Figure 1*** *- Changes in the structure of energy production from various sources in the world*

## Environmental consequences of the use of traditional energy sources

As a result of a sharp increase in world energy production, the features of its global impact on the ecology of our planet and each country are becoming more precise and more intense. The main ones are:

- ozone degradation;
- global warming;
- melting glaciers and permafrost;
- rising sea and ocean levels;
- change of sea currents;
- increase in the frequency of extreme meteorological phenomena (a sharp increase in the number of storms, hurricanes, heavy rainfall, periods of heat) (Fig. 2, 3);
- increasing the frequency of floods increasing frequency of floods;
- reduction of the Earth's biological diversity and loss of its biosphere reduction of the Earth's biological diversity and loss of its biosphere;

- food shortages in many countries food shortages in many countries;

- spread of epidemics spread of epidemics;

- increasing number of military conflicts and refugees increasing number of military conflicts and refugees;

- the cost of compensation for losses due to weather, meteorological phenomena, epidemics, social and political cataclysms increase in the price of compensation for losses due to weather, meteorological phenomena, epidemics, social and political cataclysms.

***Figure 2*** *- A hurricane of dust engulfs the city*

***Figure 3*** *- Huge emissions of smoke cause frequent smog*

It is clear that if we do not take urgent measures, the environmental catastrophe, sooner or later, will affect our entire planet. It is clear that the ecological disaster, sooner or later, will cover our whole world (Fig. 4).

***Figure 4*** *- What fate are we preparing for the future of the planet Earth?*

**Ukraine's energy sphere and its impact on the global environment**

The structure of Ukraine's energy resources is currently described by the following fundamental indicators of annual energy production:

- nuclear power plants - about 85 billion kWh nuclear power plants - about 85 billion kWh;
- thermal power plants - about 50 billion kWh thermal power plants - about 50 billion kWh;
- thermal energy centers and cogeneration units of thermal energy - about 12 billion kWh;
- hydroelectric power plants - about 8 billion kWh;
- solar and wind power plants - about 3 billion kWh;
- small hydropower - about 2 billion kWh;
- other power units - about 1.5 billion kWh.

In total, this is about 1% of world energy production. At the same time, Ukraine occupies about 0.5% of the world's territory, and its population is also about 0.5% of the world's population. From this, we can conclude that our country must solve global energy and environmental problems of the world on a par with all other countries.

For comparison, the world share of energy production in the United States exceeds 20%, and the share of its territory is 6%. This country must make a much more significant contribution to solving the global problems we have outlined.

Thus, both for the whole world and for Ukraine today is characterized by limited energy resources, the high cost of various types of energy, and the negative impact on the environment of all processes of its production (Fig. 5). A critical analysis of all these factors allows us to draw an essential conclusion today: it is wiser to reduce energy consumption and ensure its more efficient use than constantly increasing its production in our country.

***Figure 5*** *- The most significant environmental impact at the Chernobyl nuclear power plant*

## ACTIVITY OF THE WORLD COMMUNITY TO ENHANCE ENERGY SAVING

Thus, energy saving is becoming more and more an urgent local and global problem of sustainable development of all humankind. The year 2010 can be considered the beginning of a sharp increase in the activity of the world community on energy efficiency and preservation of the world environment. At this time, most Nobel laureates gathered for their annual conference in Stockholm and addressed the UN. This address stated that Earth had entered a new geological era where human activity is a significant factor in global environmental change. Such changes can lead to drastic and irreversible consequences for humanity and the ecosystem of the entire planet. In this regard, the Nobel laureates recommended many urgent and far-reaching global actions to preserve the Earth for future generations.

The UN Conference on Sustainable Development adopted the memorandum proposed by scientists in 2012. Its solution covers many social, economic, political, and environmental proposals (Fig. 6). One is to disseminate and promote scientific, ecological, and energy literacy, especially among young people.


***Figure 6*** *- The main components of sustainable development of humankind*

A fundamental problem for humanity is the significant reduction of carbon dioxide emissions (Fig. 7), a significant factor in global warming on our planet. Such warming is already seriously felt in different regions of the globe (Fig. 8). In 2015, the UN Climate Change Conference adopted an international climate agreement - the Paris Agreement, which replaced the previous similar document - the Kyoto Protocol. At the end of 2016, the Paris Agreement entered into force. The main goal of the Paris Agreement is to keep the global temperature on Earth within 2 ° C by 2100. The parties to the agreement must reduce their carbon dioxide emissions by about 5.5% annually to achieve this goal. The main direction of achieving this goal is the global transition to clean energy and various energy-saving methods. This puts in front of the world energy the need for a sharp change in the structure of energy sources and equipment with replacing traditional sources with non-traditional or renewable sources. As for Ukraine, in Paris, our country announced reducing CO2 emissions by 40% by 2030 relative to 1990 emissions.

***Figure 7*** *- Hundreds of powerful thermal power plants in the world emit millions of tons of carbon dioxide into the atmosphere every year*

***Figure 8*** *- In different countries, global warming is already affecting the number of agricultural products*

In 2020, a European interstate program for a sharp increase in the use of renewable energy sources was developed. This program has set a rather ambitious goal: to achieve a complete transition to renewable energy sources in 2050 under favorable political and

economic conditions. To date, about ten European countries have joined the program.

Ways to solve the energy as mentioned above and environmental problems in the Carpathian region were discussed during the specially organized 2020 Round International Tables. We will briefly analyze the main events of these events and the main results of their implementation.

## ROUND TABLES ON ENERGY SAVING AND ENERGY AUDIT IN UZHHOROD

A round table on projects implemented by organizations and institutions of the Zakarpattia region in the framework of cross-border cooperation programs was held in Uzhhorod at the Uzhhorod National University Rector's Office (Fig. 9). The forum was attended by Uzhhorod National University, Tisza River Basin Department, Agency for Sustainable Development of the Carpathian Region 'FORZA', Agency for Regional Development and Cross-Border Cooperation Zakarpattia,' Regional Children's Hospital, Association for Small and Medium Business Development and Innovation. 'Uzhhorod XXI century. '


***Figure 9*** *- Round table discussion on cross-border cooperation*

Oleksiy Petrov, Head of the Zakarpattia Regional State Administration, Mykhailo Rivis, Head of the Zakarpattia Regional Council, Bohdan Andriyiv, Mayor of Uzhhorod, and Volodymyr Smolanka, Rector of Uzhhorod National University, addressed the participants of the Round Table with salutary speeches.

Speakers from the Round Table spoke in detail about cross-border projects implemented by the city of Uzhhorod with sister cities, presented critical infrastructure and soft projects aimed at developing socio-economic infrastructure of Zakarpattia, preserving the environment, improving health, conserving the cultural and historical heritage of the region and individual territorial communities. During the meeting, they also discussed the possibilities of cooperation with regional authorities to address administrative and organizational issues of implementation of innovative projects, their financial and methodological support.

Within the framework of the CBCSmartEnergy project, a round table on energy saving and energy audit was held with the participation of project executors, experts from Ukraine and Romania, scientists, researchers, representatives of the regional administration, and some territorial communities of Transcarpathia (Fig. 10).

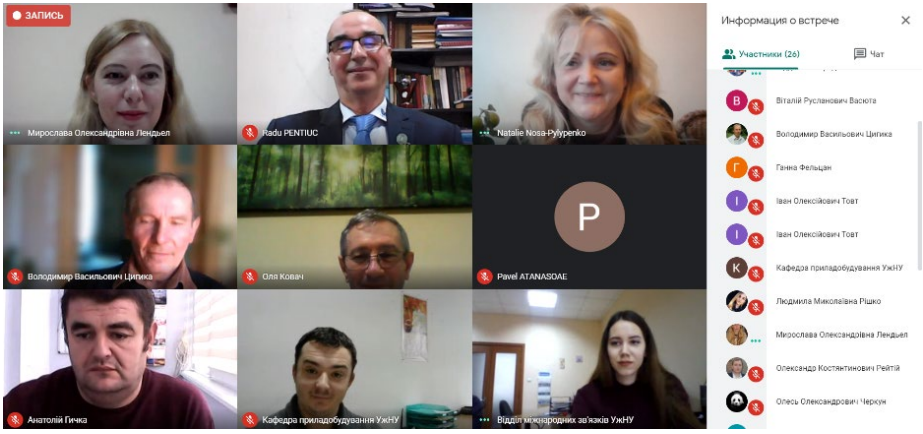


***Figure 10*** *- Round table discussion within the CBCSmartEnergy project*

The Round Table was attended by 8 project partners from Romania, 20 participants from various organizations of Uzhhorod,

and 10 students of Uzhhorod National University. The most relevant topics of the Round Table, which sounded in the reports, were:

- exchange of experience of Romanian colleagues in conducting energy audits of various objects of territorial communities and defining energy-saving strategies for them;
- introduction of innovative approaches to energy saving in municipal buildings;
- main directions of local policy of territorial communities of Transcarpathia in the field of energy-saving and energy efficiency;
- perspectives and action plans on sustainable energy and climate as an intersectoral priority of the 'Uzhhorod-2030' City Development Strategy,
- mechanisms of broad involvement of territorial communities of border regions in energy-saving processes and others.

The roundtables were essential events in achieving the overall goal of the CBCSmartEnergy project and the widespread application of best practices in the use of smart energy in the border area between Ukraine and Romania. At the same time, most of the speakers and participants of the project noted that the planned measures for energy conservation and energy efficiency of cross-border cooperation should be consistent and harmonized with the leading global trends in solving the global climate and economic problems of humankind. Therefore, it is advisable to briefly analyze these trends and possible features of their widespread implementation in the territorial communities of Ukraine and Zakarpattia.

## DIRECTIONS OF INCREASING ENERGY SAVING AND SOLVING ENVIRONMENTAL PROBLEMS IN THE WORLD

The need to increase energy savings and eliminate environmental problems will require many countries (especially industrialized ones) high economic costs and a radical reduction in hydrocarbons. As a result, today, world energy faces the urgent need to drastically change the structure of energy sources, which are widely used in the national economy and in the municipal sector. In such conditions, most analytical research provides the following main directions of future energy development:

- a significant (up to 50%) increase in the share of non-traditional renewable energy sources in many countries over the next 20-30 years;
- a sharp reduction in various costs for the introduction of new energy generating capacity;
- a steady and constant increase of efficiency of use of all types of energy, irrespective of a kind of a source of its reception;
- introduction of energy-saving and energy-efficient technologies in all spheres of public and private life.

At the same time, the following are the essential types of global energy-saving measures.

1. Technical, which are reduced to the development of implementation and use of energy-efficient and energy-saving devices and technologies:
   - in energy production;
   - in energy transportation;
   - in energy usage;
   - in energy saving (for example, thermal insulation of premises and buildings).
2. Economic, the main of which are:
   - application of different energy tariffs in other parts of the day;

- application of progressive billing (you consume more - you pay at a higher rate);

- application of state programs to encourage the introduction of energy-saving technologies.

3. Organizational:

- installation of multi-tariff and intelligent energy meters;

- use of winter and summertime features;

- introduction of various modes of the economy of all types of energy.

4. Legal, based on the implementation of various national and international energy-saving programs and agreements.

## STATE OF SOLVING ENERGY SAVING PROBLEMS IN UKRAINE

The enormous economic potential of energy saving in Ukraine is due to the rapid payback and proper return on investment in energy-saving small amounts of money. These costs are much lower compared to the proposed costs of increasing energy production. The Energy Strategy of Ukraine defines the main principles of the policy on efficient use of energy resources until 2030 and other legislative acts.

In the cities of Ukraine, surveys and opinion polls are conducted on the level of housing and communal services, the possibility of increasing the payment of the population for better quality services, the level of satisfaction of residents with the services provided. Special measures are also being taken to restructure and reform utilities. Software and information technologies for objective accounting of consumption of various resources by enterprises, organizations, and individual households are developed and improved. For example, the 'Energoplan' program for accounting and analyzing energy and natural resource efficiency in public buildings is becoming widespread. At the same time, active, multifaceted work in this direction in Ukraine is just beginning.

In 2009, at the initiative of the 'Energy Efficient Cities of Ukraine' Association, the first 10 cities of Ukraine (Artemivsk, Dolyna, Kamyanets-Podilsky, Kherson, Kovel, Lutsk, Lviv, Pervomaisk, Voznesensk, Zhmerynka) joined the pan-European initiative known as 'The Covenant of Mayor.' It provides for a reduction in energy consumption by local communities by 20% every 10 years. To date, more than 300 different levels of territorial communities of Ukraine have joined this agreement. Unfortunately, only 6 territorial communities of Zakarpattia region are among them. This fact already testifies to the huge prospects for the inclusion of young people in our region in energy saving. The Association 'Energy Efficient Cities of Ukraine' has primarily contributed to this.

In general, the objective prerequisites for the efficient use of energy resources in Ukraine are the following:

- relatively low level of development of the country, which causes insignificant costs to improve the environment;
- emergence and strengthening of some aspects of the ecological and raw materials crisis;
- constant rise in the price of all types of energy resources;
- increasing the use of energy resources through urbanization and rising living standards;
- low level of introduction of energy-saving and environmentally friendly technologies;
- the presence of large volumes of secondary raw materials and waste;
- high potential of non-traditional and renewable energy sources.

## Features of energy-saving development in the municipal sphere and within specific territorial communities of Ukraine

Municipalities, local communities, and individual households have a unique role in solving energy-saving problems in Ukraine. Our state is characterized by some features of solving the issues outlined, and note the main ones:

- the existence of social, industrial, administrative, legal, and market barriers to the implementation of various energy-saving mechanisms;
- weakness of local economies of territorial communities;
- archaic management system of municipal enterprises, focused on subsidized financing schemes and planned and costly management methods;
- inconsistency of structures and management systems of municipal enterprises with the conditions of Ukraine's integration into the world economy;

- imperfection of the structure of housing and communal services, in which several thousand enterprises and organizations operate and almost a quarter of the state's fixed assets are operated;

- constant deterioration of the housing stock;

- most fixed assets and equipment for heat, water supply, and sewerage have been depreciated to a critical level;

- vague and unclear transition from the non-market sector to private enterprise in the supply of energy resources;

- discrepancy of incomes and expenses of inhabitants for the maintenance of apartment houses and adjacent territories;

- inconsistency and ambiguity of current legislation on the distribution of state budget resources between budgets of all levels;

- lack of effective control over the use of funds from the development budget of cities and territorial communities;

- lack of independence and initiative in the search for advanced management methods and energy-saving;

- inefficiency of the motivational mechanism of encouragement and weak use of economic levers of energy saving in all spheres of the public life of communities;

- insufficient qualification and motivation of employees involved in the energy efficiency of municipal farms;

- vagueness of current legislation on the provision of loans for energy-saving measures.

## REASONS FOR LOW EFFICIENCY OF IMPLEMENTATION OF ENERGY-SAVING MEASURES IN UKRAINE

### Reasons of political and legal nature

Wrong political decisions and actions often lead to the discrediting of energy-saving ideas in the eyes of Ukrainian citizens. Among the main ones, we will note.

1. Low state priority of problems of improving energy efficiency.

2. Inefficient and corrupt use of state and municipal funds.

3. Social maintenance of some segments of the population and individuals due to unreasonably high payments from the state budget.

4. There is a lack of precise control over the loss and theft of energy resources at different stages of production, transportation, and use.

5. Substitution of the concept of 'efficient use of energy' by the idea of 'energy saving.' As a result, a reduction in energy consumption is often initiated due to the deterioration of the quality of energy services of municipal enterprises and organizations. The use of such means and approaches to energy saving only harms the regional economy, business, and private interests of the inhabitants of territorial communities.

6. Underestimation of energy-saving efficiency by the end-user among state and local leadership. World experience shows that the modernization of schools, hospitals, residential buildings has a much higher potential for energy savings than the production and transportation of energy.

7. The dependence of municipalities in the formation of financial policy and the use of their own budget on the decisions of public authorities remains strong.

8. Due to the shortcomings of the housing and civil legislation system in Ukraine, a reliable and efficient owner of apartment

buildings, where more than 90% of residents of large cities live, has not been created.

9. Restriction of the current legislation on the possibilities of territorial communities to dispose of communal property, particularly restricting the rights to alienation, re-profiling, and leasing of buildings and institutions of the education and health care system.

10. Preservation of the ban on unlocking some state and social facilities from energy supply.

11. Lack of quality control of energy resources provided to consumers (for example, gas calorific value, electricity quality, etc.).

**Reasons of managerial nature**

These reasons lead to a low level of energy efficiency in the heads of municipalities and local communities.

1. Low priority of energy efficiency issues in strategic community development plans.

2. Lack of highly qualified technical and financial analysts and managers who are able in the current conditions to draw up a plan for the development and rehabilitation of the community economy through energy-saving activities.

3. Deficient level of energy consumption monitoring in some objects of territorial communities on the factors influencing energy consumption by these objects. As a result, there are virtually no important regional energy saving indicators, such as annual fluctuations in weather conditions and multi-year databases on energy consumption from various traditional and renewable resources.

4. Imperfection of the energy consumption management system, where administrative levers set energy and energy consumption limits.

**Reasons of a technical nature**

1. Dominance of technical and technological solutions at communal facilities of territorial communities, which do not provide for accounting and regulation of the consumption of different types of energy during the provision of energy-intensive services.

2. Insufficiency of meters for consumption of various types of energy by final public consumers (administrations, schools, hospitals, children's institutions, etc.).

3. Weak awareness of modern energy-saving equipment and materials market by design engineers who can make technological changes in the used utilities and systems.

4. The difficulty of combining new energy-saving technical components with old worn-out mechanisms and technological equipment, which are part of the existing municipal facilities of the energy sector.

**Reasons of economic and financial nature**

1. Incompatibility of market conditions and general administrative and bureaucratic approaches to municipal governance.

2. Deficit of most local budgets. Insufficient funds of local budgets for energy-saving measures;

3. Lack of opportunity to increase revenues from the sources of territorial communities due to the intense pressure of state taxes on residents.

4. Imperfection of real estate tax.

5. Imperfection of financial and economic evaluation mechanisms of projects to increase energy efficiency and energy use.

6. Imperfect and corrupt system of budgeting of territorial communities, which does not allow planning and controlling energy consumption effectively. The budget often lacks realistic planning for energy expenditures and the maintenance of various energy systems, such as street lighting, support for urban electric transport, etc.

7. There are no transparent schemes for calculating energy savings and funds during energy-saving measures in local communities. There are also no mechanisms for accumulating budget savings saved due to energy-saving projects for modernization and further improvement of energy systems.

8. Administrative restrictions on the purchase of energy-saving equipment and materials of foreign production.

**Reasons of a social nature**

1. The presence of many urgent social problems pushes the issue of improving energy efficiency in the background. But it should be understood that in our time, energy conservation is becoming an essential component of solving socio-economic problems: dark streets contribute to banditry, cold schools - increase morbidity and make it impossible to organize full-fledged education and more.

2. Low social, economic, technical, and moral culture of the inhabitants of territorial communities. As a result, many citizens behave on the principle of 'It's neither my headache nor my piece of cake.' in matters of energy saving.

3. Irresponsible consumer attitude to local natural energy resources prevails in most territorial communities (especially remote ones). As a result, forests belonging to this territorial community are being destroyed with impunity and for almost nothing.

4. Thefts of energy resources by individual citizens of territorial communities (unauthorized connections to electricity networks, use of powerful magnets to affect meters, etc.) remain pretty common.

## THE FUTURE - FOR NON-TRADITIONAL RENEWABLE ENERGY SOURCES

### Traditional and non-traditional energy sources and energy saving

Traditional energy sources are divided into non-renewable (or fossil) and renewable. The former mainly include various types of coal and peat, natural gas, oil, and uranium. Renewable traditional sources include hydropower and wood in various forms for incineration.

Modern energy is mainly based on non-renewable energy sources, which, having limited reserves, are depleted and can not guarantee the sustainable development of world energy in the long run. Their use is one of the main factors of global environmental degradation.

Most experts believe that increasing global energy needs will deplete traditional energy resources by the middle of this century. Technical progress, development of new hard-to-reach deposits (deep-water and polar deposits, etc.) will only postpone the depletion of resources for a short time. It should be borne in mind that even if the reserves of traditional energy resources are not completely depleted, in 20 - 30 years, there may be a significant shortage and a sharp rise in prices.

Non-traditional (alternative) energy sources include the flow of solar radiation, wind, the heat of the Earth, biomass, the movement of the aquatic environment of the seas, oceans, rivers, etc. (Fig. 11). All these sources are renewable because they constantly exist or periodically appear in the environment and in the foreseeable future are almost inexhaustible.


***Figure 11*** *- The primary alternative energy sources of Ukraine*

It should be noted that some scientists include peat fuels as renewable energy sources. However, in our opinion, peat is more appropriate to consider a traditional fossil fuel, as thousands of years pass for the formation of its significant economic reserves.

Renewable energy sources of rivers include only those water flows on land that are used to install mini- and micro-hydropower plants with a capacity of less than 1 MW. It is believed that special dams should be built for higher power hydropower plants. And this requires the removal of large plots of land without their renewal and leads to irreversible changes in fauna and flora in these areas.

For comparison, we give the energy consumption of different renewable energy sources in terms of one square meter of this type of energy flow area.

1. The energy flux density of the Sun's radiation on the earth's surface is about 1 kW/m2.

2. The density of wind energy flow (at a speed of about 10 m / s) - about 0.6 W/m2.

3. The energy density of geothermal heat flow on the Earth's surface is about 30 · mW/m2.

4. The energy flux density in a nuclear power plant reactor is about 0.2 MW/m2.

Indicative indicators of energy resources of renewable energy sources in Ukraine are given in Table 1.

***Table 1*** *- Energy potential of renewable energy sources in Ukraine*

| Поновлювані енергоресурси | Показники, млрд. т ум. пал./рік | |
|---|---|---|
| | Технічний | Економічний |
| Променева енергія Сонця | 5 | 1 |
| Теплова енергія морів і океанів | 1 | 0,1 |
| Енергія вітру | 5 | 1 |
| Гідроенергія, у тому числі: | | |
| енергія водотоків* | 4,5 | 2,6 |
| енергія хвиль | 0,05 | 0.01 |
| енергія припливів | 0,7 | – |
| Енергія біомаси (за виключенням дров) | 2,55 | 2,0 |
| Геотермальна енергія | 0,4 | 0,2 |

## Trends in world development of unconventional energy

Developed countries of the world have been investing billions of dollars annually in developing non-traditional energy sources for many recent years. There are government programs to support the development of renewable energy sources. In particular, in 2015, the world's unconventional renewable energy produced energy with a total capacity of about 785 GW, and the volume of annual investment in this industry reached 286 billion US dollars. By 2025, the annual growth of world electricity production from traditional sources is planned to be 2.8%, and from alternative sources - by 9.2%. At this rate, the nature of changes in the energy use structure in the world by 2050 is illustrated in Figure 12.

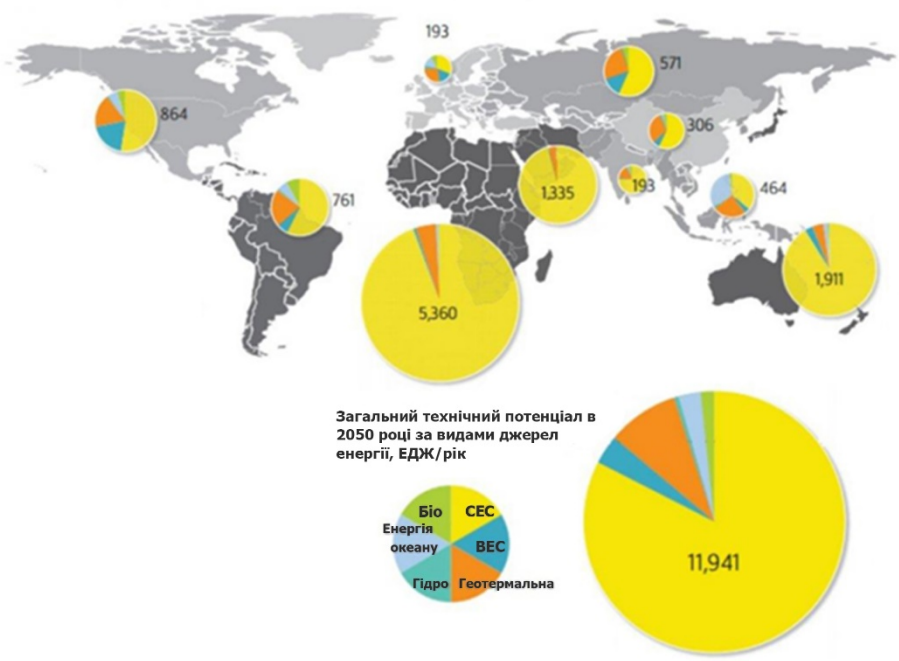


***Figure 12*** *- Planned to realize by 2050 the potential of renewable energy sources of individual countries and around the world*

## Energy-saving features for renewable energy sources

Renewable energy sources contribute to energy conservation not directly but indirectly. And the tangible economic effect of energy saving is not felt immediately, but only in the relatively long term. At the same time, the maximum manifestation of the efficiency of non-traditional energy should be expected in 5 - 10 years after its technical implementation. After the same period, the negative environmental impact of most non-traditional energy sources practically disappears.

The impact of negative energy factors from renewable sources should also be taken into account. The main ones, as a rule, include a significant unevenness of energy production over time

during the day and year, relatively high capital intensity of power plants, use of land plots of a large area. However, in any case, to ensure efficient energy saving when using renewable sources, it is necessary:

- to conduct systematic studies of the environment of the region where the installation of appropriate equipment is planned;
- to study the needs of a particular region in energy for industrial and agricultural production and domestic needs. In particular, to choose the most economical source of energy, you need to know the structure of energy consumers.

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## ENERGY AUDIT - ORGANIZATIONAL BASIS OF COMPREHENSIVE SOLUTION OF ENERGY-SAVING PROBLEMS

The introduction of energy-saving technologies and projects in all sectors of the economy and the utility sector is no less important for Ukraine than the increase and reduction in the cost of domestic energy production.

A significant increase in the cost of energy and fuel has led the country's authorities to realize the need to accelerate the pace of energy efficiency projects and activities. This is evidenced by many vital laws and regulations of our state's government adopted in recent years. At the same time, the main emphasis in the organization of energy-saving measures is on energy audits.

For our country, the process of conducting all energy audit activities has its own characteristics:

- a relatively wide range of factors that need to be examined at the stage of preparation and conduct of energy audits, as well as in the development of energy-saving projects based on the conclusions of energy audits;
- the complexity of the technical analysis of most facilities, especially in the utility sector, to select the optimal combination of energy-saving measures;
- limited ability to apply the solutions of energy-saving problems typical for other developed countries due to the strong dependence of the level of energy consumption on various external and internal factors;
- lack of precise and proven economic and motivational mechanisms and management methods that shape the energy-saving behavior of utility personnel;
- a minimal number of experienced technical staff who can conduct high-quality energy audits of various facilities, as well as know the modern technical and technological aspects of energy-saving;

- a need in many cases to use unique and non-standard energy-saving technologies.

## DEVELOPMENT OF ENERGY-SAVING, ENERGY AUDIT, AND RENEWABLE ENERGY OF TRANSCARPATHIA

Each region of our country has its own characteristics of solving problems of energy-saving and ecology. Let's analyze this issue for Transcarpathia, although, in our opinion, such an analysis is relevant for the entire international region of the Carpathians. Consider the main features of their categories.

1. Creating economic interest of all government agencies and municipal facilities in improving energy efficiency. Today in Zakarpattia region, such genuine interest is practically absent, except for purely economic projects of 'pumping' of budgetary funds in private firms at the expense of 'green tariff.' An example is robust solar power plants and projects to construct wind farms on high-altitude meadows (in particular, on Borzhava).

2. Develop a system of new regional energy standards and implement a system of independent expertise on energy saving in all areas of regional management, public life, and maintenance of private residential buildings.

3. Establishing the financial and legal responsibility of officials, facility managers, and individuals for inefficient use of fuel and energy resources, especially for their 'squandering.' For example, the imposition of progressive tariffs for excessive use of all types of energy resources, significant fines for the operation of street lighting during the day and the use of faulty internal combustion engines, and so on. The funds received will be used only for energy-saving activities in the region.

4. Establish effective quality control of all energy resources and services provided to municipal facilities (calorific value of natural gas and other fuels, quality of electricity, etc.).

5. Master new sources and mechanisms of financing energy-saving projects and intensive investment in this area in all areas of activity of territorial communities.

6. Expand the range of business partners for energy-saving and strengthen their interaction, introducing a wide mutual exchange of experience in sustainable energy development of local communities.

7. Intensively participate in implementing European and global initiatives on energy security, sustainable community development, and a healthy environment.

8. Comprehensive development of the waste and garbage processing industry with simultaneous planned cleaning of the whole environment.

Energy-saving and cleanliness of the environment become the business of every member of society and the territorial community in all activities (Fig. 13). This is especially true of the younger generation, who today take responsibility for the future of their loved ones and the entire planet. However, often we do not even pay attention to what surrounds us and how the results of our actions will be manifested in our near or distant future. Each of us encounters energy-saving issues at every step of our stay at work, at home, or in public places. Pay attention to the figure - how many valuable things can be done in the direction of energy-saving right now without making much effort.

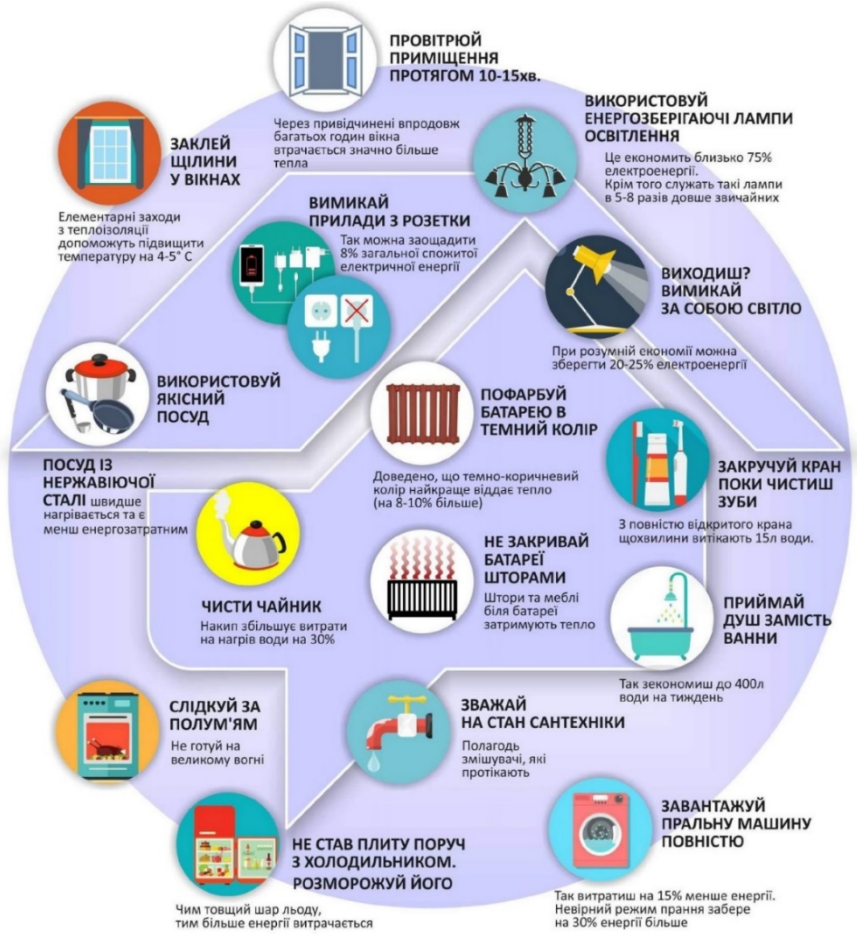


***Figure 13*** *- Energy saving should start with yourself*

Each energy source has its own properties: cost, quality, ease of transportation and use, ease of conversion into the required valuable energy, environmental impact. Therefore, the problems of energy conservation and protection of the immediate environment are related to all these properties and must be addressed comprehensively. And in many cases, to begin to solve these problems should be the destruction of the usual mismanagement of energy use by each of us at all levels of the social life of communities

- from life to the operation of large enterprises and organizations (Fig. 14).

***Figure 14*** *- What can I do for our planet today !?*

It is clear that for effective and high-quality energy-saving measures at all levels from their homes to the whole country, young people need knowledge and practical skills in modern energy management and energy audit. To this end, the Faculty of Engineering and Engineering of Uzhhorod National University, within the framework of the CBCSmartEnergy project, is launching some new unique disciplines in educational programs, including 'Energy Management with Energy Audit,' 'Resource Saving Energy,' 'Automation of Power Systems' and others. We will consider the introduction in the educational process of basic energy-saving discipline 'Energy management with energy audit' in more detail.

## HAVING KNOWLEDGE - MEANS EING ARMED

At the beginning of October 2020, within the framework of the CBCSmartEnergy project, the involvement of students of the Faculty of Engineering and Technology in the development of a new field of knowledge and practical activities for us - energy management began. At the first organizational lesson (Fig. 15), the students met the main executors of the project, who introduced the participants to the main areas of student participation in this project.

***Figure 15*** *- We begin to learn energy management*

Myroslava Lendiel, Vice-Rector of Uzhhorod National University and project manager, noted that: during the preparation of the project materials, a unanimous decision was made to cooperate with the Faculty of Engineering and Technology which has the most specialties in engineering. And, as experience shows, this problem in the countries of the European Union is dealt with by those faculties of universities that train future engineers. At the same time, students' theoretical training is expected, and their direct

participation in conducting energy audits of UZhNU buildings, mastering work with modern equipment and devices for energy auditing, mastering best practices and methods of energy auditing at the University of Suceava Stefan cel Mare. Zakarpattia and Romania apply and promote the basic techniques of energy saving that are available to everyone.

***Figure 16*** *- Modern energy audit - a tight combination of engineering theory and practice*

To date, as part of the project, a curriculum for a new engineering discipline for Uzhhorod National University, 'Energy Management with Energy Audit,' has been developed. The discipline content provides the study of methods of analysis of the state of consumption of different energy sources at different objects of the national economy and municipal buildings and the development of recommendations for improving energy efficiency. It is planned that as a result of studying the discipline **students should know:**

- methodology of an energy audit;
- critical basic energy consumers;
- energy meters and time meters of physical quantities;
- principles of proper organization of energy flows at different facilities;
- methods of verifying energy consumption data.

In addition, as a result of studying the subject**, students should be able to:**

- determine the current state of energy use at the facility;
- analyze the efficiency of energy use at the facility;

- make a description of enterprises and buildings;
- give recommendations on efficient energy use;
- make an energy audit report.

For a more detailed acquaintance with the discipline's content, we present its working program developed by the project executors.

**The program of the discipline** 'Energy Management with Energy Audit.'

Content module 1. Tasks and methodology of energy audit

**Topic 1.** Introduction purpose of an energy audit. Energy-saving potential. Energy efficiency.

**Topic 2.** Laws of Ukraine on activities in the field of the energy audit. General provisions. Certification and licensing of energy audit activities. Chamber and Union of Energy Auditors of Ukraine. The procedure for conducting an energy audit. Rights and responsibilities of energy auditors and energy audit companies. Compliance monitoring and liability for violations of energy audit legislation. Financing and stimulation of energy audit activities.

**Topic 3.** State standards for energy audit and their scope. Requirements for the composition of energy audit work. Requirements for the analysis of the economic situation of the enterprise and its specific energy consumption. Energy audit report. Organization of energy audit work. Recommendations for the selection of enterprises for the energy audit.

**Topic 4.** Methodology of the energy audit. Stages of the energy audit. Methods of the energy audit. Methods for calculating electricity losses.

**Topic 5.** The amount of energy consumption, its cost according to the documentation of the object. Determination of the current state of energy consumption and its value. System of tariffs for energy supply and energy carriers.

**Topic 6.** Energy inspection of the object by auditors. Scheme of technological process. List of the most important energy consumers.

Content module 2. Analysis of energy use and recommendations for energy saving.

**Topic 1.** The current state of energy use. Methods of measuring energy consumption and energy. Stationary and temporary meters. Method of regression analysis and test control. Estimation of energy consumption by technological equipment and lighting systems.

**Topic 2.** Energy flows on the object. Analysis of energy flows in a steam boiler, heat exchanger, refrigeration unit. Estimation of liquid and gas flows at economical speed in pipelines.

**Topic 3.** Comparison and cross-checking of energy consumption data. Input-output fuel and energy balance. Mass balance. Cross-check on energy efficiency—verification by comparison with typical performance indicators.

**Topic 4.** Analysis of energy efficiency at the facility. Annual purchase and consumption of fuel and energy report. Graphs of changes in energy consumption over time and regression analysis. Energy audit table. Fuel cost ratios. Shadow chart. Pie charts of energy consumption.

**Topic 5.** Description of enterprises and buildings. Energy supply to the facility. Energy conversion equipment. Energy distribution. Energy consumption equipment. Construction and structure of buildings.

**Topic 6.** Recommendations for energy efficiency. Losses in the generation, conversion, and distribution systems. Final energy consumption. Influence of energy consumption systems on energy efficiency. Energy balance of the object.

## ENERGY AUDIT OF UZhNU BUILDINGS

On December 1, 2020, within the framework of the CBCSmartEnergy project, the energy audit of three university premises began. The initial event was a meeting of the project executors and the audit firm's management with students of the Faculty of Engineering (Fig. 17), the primary purpose of which was to acquaint students with the general energy audit procedure.

***Figure 17*** *- It is exciting and useful to get information directly from a professional*

The report of the technical director of the Adamson company Mykola Stashko sounded meaningful and exciting at a meeting. This company from Ivano-Frankivsk won the tender for energy audit services of UzhNU buildings. Furthermore, Adamson's energy auditors were the only ones in Ukraine certified by a foreign

certification center: the leading US energy audit institute - The Building Performance Institute. Mykola Stashko spoke in detail about the specifics of the company, the principles of its work in the energy audit of buildings of various organizations, the devices used for the energy audit, the conditions of cooperation between the company and customers, and much more. Many problematic issues were also discussed by students, project executors, Mykola Stashko, and Uzhhorod National University Chief Energy Manager Anatoliy Hychka.

But the most interesting was the practical part of the event. For three days, Adamson specialists, with the active participation of students, conducted a complete energy audit of three buildings of Uzhhorod National University: the Faculty of Chemistry, Biological Faculty, and Students` Dormitory No.2 (Fig. 18). As a result, the current state of engineering networks of heating, lighting, ventilation, and water supply was examined, based on which a general description of the energy parameters of the buildings was made. The information obtained during the survey was compared with the architectural and technical documents on the building. However, the main thing in the energy audit is to conduct numerous specific measurements of energy loss of the building through various channels: through windows, walls, ceiling, roof, front door, basements, and utility rooms that are not heated by a heating system, etc. Various defects of structural elements of buildings, particularly the presence of cracks, arrangement of 'bridges' of cold, and placement of components with high thermal conductivity, were especially carefully investigated. The whole array of collected data is the input information for further energy calculations and analysis of energy losses of buildings.

***Figure 18*** *- Master class on working with a thermal imager at the Faculty of Chemistry, measurement of ventilation parameters in the dormitory, and external thermal imaging study of the Biological Faculty*

Particular attention in research is paid to heat loss due to air circulation in the gaps between different rooms and ventilation. Due to these components, a lot of cold air enters the room, which must be additionally heated, consuming a significant amount of thermal energy.

The primary purpose of large-scale detailed energy audit studies is to obtain accurate energy data about the building. Based on this information, specialized computer programs calculate the set

of energy parameters of the building. The obtained parameters are the basis for the energy auditors to conduct a complete analysis of the energy status of the object of study. The result of such an analysis is a comprehensive report, which is the primary legal document for further any action on energy and structural modernization of the building.

The energy audit report:

- gives main ways of heat loss in the building established by auditors;
- develops the main ways of heat loss in the building established by auditors results, the methods which will allow minimizing energy leaks;
- indicates the ways of bringing the energy parameters of the building to the indicators declared in the current regulations;
- provides recommendations for energy management through the use of new technologies and innovations;
- provides basic economic calculations of the cost of various measures to improve the energy efficiency of the building.

## INNOVATIVE LIGHTING AT THE BIOLOGICAL FACULTY AND FACULTY OF CHEMISTRY OF UZhNU

An essential task of the CBCSmartEnergy project is to facilitate the transition of various buildings of Uzhhorod National University to innovative lighting to reduce electricity consumption shortly. The most promising energy-saving modern lighting systems are LED, which are based on the use of artificial light sources such as light diodes (Fig. 19).

***Figure 19*** *- LED panels for lighting classrooms and laboratories*

LED luminaires have some advantages over other more traditional light sources.

1. Highest energy efficiency. For comparison, when providing a given level of the luminous flux of 100 lm for LED lamps, it is enough to spend 0.8 W of electricity, while for fluorescent lights - about 1 W, and for incandescent lamps - from 4 to 6 W.

2. LED lamps do not heat as much as incandescent lamps.

3. LEDs are powered by direct current and therefore give a highly stable non-flashing light flux.

4. The service life of LED lamps is 50 times longer than incandescent lamps.

5. LED lamps are 2-3 times smaller than other types of lighting with the same luminous flux.

6. LED lamps to have a reliable anti-shock design. At the same time, halogen lamps and incandescent lamps are straightforward to beat.

7. LED lighting is more environmentally friendly and safer. In particular, fluorescent lamps contain mercury vapor harmful to humans and the environment in their bulbs.

8. The radiation spectrum of LED lamps can be adjusted to the range of natural sunlight, which is the most comfortable for humans.

9. Electrical networks and switching devices are used to power LED luminaires, subject to much lower bandwidth requirements.

Thus, energy-saving and modern lighting are closely interrelated aspects of our daily lives. Accordingly, the CBCSmartEnergy project solves such an urgent task as the optimal organization of lighting of workplaces of students and research and teaching staff of the university, which will have a positive impact on their health. This decision is critical because, according to statistics, a person spends about a third of his life on the premises at work (offices, classrooms, shops, laboratories, etc.). Therefore, considerable attention should be paid to ensuring appropriate visual conditions in the workplace. The use of LED lighting allows you to solve the outlined problems effectively. This is since the workplaces of research and teaching staff, and students require uniform lighting with the necessary level of light flux. With the help of LED lamps, this is easily achieved by combining familiar and local light sources, taking into account their mutual location and directions of individual light fluxes.

Within the framework of the CBCSmartEnergy project, a complex modification of the lighting system of the two faculties is carried out, in which, in addition to energy-saving, other important points are taken into account:

- required levels of lighting in the workplace;
- safety of the entire lighting system;

- reliability of electrical appliances;
- architectural features of the premises;
- psychological favorableness of the internal space of the premises.

## DYNAMIC CONSTANT CONTROL OF ELECTRICITY CONSUMPTION - BASIS OF ENERGY MANAGEMENT OF THE UNIVERSITY

As part of the CBCSmartEnergy project, Uzhhorod National University has begun work to install a system of autonomous remote continuous metering of electricity used in all buildings. Execution of such works is divided into two main stages:

- installation of meters with GSM-modem on all construction sites of the university, which transmit readings via mobile internet;
- creation of a particular computer administration center with the appropriate software.

The introduction of this system will allow real-time monitoring of hourly electricity consumption at all university buildings.

Innovative commercial accounting of electricity consumed by various economic entities is currently an essential technical and financial issue of energy management. Nowadays, many such systems are offered with different methods of data transmission, reception, and collection in ASCEM (automated system of commercial electricity metering) databases. But they all require:

- identification of possible layouts of metering points and distribution of electricity,
- installation of special intelligent meters for its accounting;
- installation of appropriate communications of the data transmission system;
- installation of the leading computer unit for storing information in the form of a particular database.

Implementing the CBCSmartEnergy project of an automatic system of commercial accounting of used electricity will allow the university to quickly obtain more accurate operational information on the amount of energy consumption of its various facilities at different times of the day and season. The use of such information allows to significantly optimize the university's work in the wholesale

electricity market of Ukraine, which helps save significant financial resources.

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THE EUROPEAN UNION IS MADE UP OF 27 MEMBER STATES WHO HAVE DECIDED TO GRADUALLY LINK TOGETHER THEIR KNOW-HOW, RESOURCES AND DESTINIES. TOGETHER, DURING A PERIOD OF ENLARGEMENT OF 50 YEARS, 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.