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Market research of innovative technologies for EE and climate protection in historic buildings and areas in Ukraine

CONTENT

UKRAINE

INTRODUCTION

Energy-conservative technologies could minimize useless energy losses, which nowadays is one of the priority directions both at the state and SME levels, as well as in the tourist and private sector. It happens due to the shortage of basic energy resources, the increasing cost of their production, as well as global environmental problems. The introduction of energy-conservative technologies in economic activity of enterprises, objects of historical heritage, tourist objects and individuals at the household level is one of the important steps in solving many environmental problems - climate change, air pollution, depletion of fossil resources, etc.

Conservation of energy is the efficient use of energy resources through the use of innovative solutions that are technically feasible, economically defensible, acceptable from an environmental and social points of view, and does not change the usual way of life.

Conservation of energy is a very important task for the preservation of natural resources in the 21st century. The search for alternatives to the existing traditional methods, in order to supply needs with thermal and electric energy, is becoming today the rule of good form and a manifestation of the energy consumption culture. Technological progress makes it possible to create devices that allow to receive energy from renewable sources: the Sun, wind, heat of the Earth, etc. Improvement and mass production of such devices, steadily reduces the cost of energy derived from them. And in the near future, preference will be given to those devices and power supply systems that until recently have been considered as alternative ones.

The rapid depletion of global hydrocarbon reserves, the growing price on energy resources, the problems of environmental pollution have to form energy strategies focused on the development of alternative energy sources by the majority of developed countries.

The market of heating systems in Ukraine has reached its saturation. In the conditions of the limitation of natural resources, the great negative impact of traditional ways of energy production as well as the constant rise in prices for energy resources, special attention is paid to the issue of their economical use. That is why today government is introducing new technologies in energy field emphasizing the

necessity of energy efficiency and performance of alternative methods of energy production.

From the position of population (natural and juridical persons), the first and the most important reason to modify buildings with energy efficient technologies is the increase of prices for energy resources. Many property owners prefer autonomous heating systems. At the same time gas boilers are in the greatest demand. Such equipment occupies approximately 85% of the Ukrainian market of autonomous heat sources. Now on the market there are in large numbers gas boilers of almost all major European manufacturers. Western equipment on the market is in great demand because of its recognized quality, economical operation and long service life.

The system for the implementation of heating equipment in Ukraine is at the stage of active formation and improvement. This is due to the fact that well-known manufacturers of heat sources have already occupied a certain share of the market and consider their main task to increase the level of service for their products.

Today, many countries in the world are gradually beginning to switch to alternative biofuels, some of which are fuel pellets (or pellets). About 95% of the pellets produced in Ukraine are exported to European countries, which are their largest consumers. Every year Ukraine supplies an increasing amount of energy fuel to the biofuel market. This is facilitated by the colossal production and raw material potential of Ukraine. Many foreign investors invest in this field, in connection with which the organization of a pellet production plant is expedient and investment-attractive.

This study explores the above-mentioned systems in more detail, as well as the possibility of their use in buildings and objects of historical heritage, based on the legislative base of Ukraine and their relevance in the area of the Black Sea coast.

LEGISLATION IN THE FIELD OF ENERGY EFFICIENT TECHNOLOGIES

At the legislative level, any actions regarding the objects of cultural heritage are regulated by the *Law of Ukraine "On the Protection of Cultural Heritage."* This Law regulates legal, organizational, social and economic relations in the field of protection of cultural heritage in order to preserve it, use cultural heritage objects in public life, protect the traditional nature of the environment in the interests of present and future generations.

Objects of cultural heritage located on the territory of Ukraine are protected by the state. Also, the reconstruction, restoration and repair of cultural heritage objects are regulated by the DBN V.3.2-1-2004 “Restoration, conservation and repair work on monuments of cultural heritage”. These Regulations establish the basic requirements for restoration, conservation and repair work on cultural heritage sites.

These Regulations spread on all types and stages of work on restoration, conservation, rehabilitation, repair, museumification and adaptation of monuments of city planning and architecture, history, archaeology, science and technology and monumental art, with the exception of artistic restoration works.

Requirements of Regulations are mandatory for all bodies of protection of monuments, owners of monuments, design and restoration, research organizations, architectural workshops, construction and restoration organizations, other legal entities and individuals, regardless of their subordination, who are directly involved in the preservation and restoration of monuments.

Normative framework of energy field in Ukraine is presented by the following Laws:

- “On Alternative Types of Liquid and Gas Fuel” from 2000;
- “On Alternative Energy Sources” from 2003;
- “On Energy Industry” from 1997;
- “On Energy Saving” from 1994;
- “On Heat Supply” from 2005;
- “On Combined production of heating and electric energy (co-generation) and usage of residual / waste energy potential” from 2005;
- “On amendments to some laws of Ukraine regarding the promotion of the production and use of biofuels” from 2009;
- “On Coalbed Gas (Methane)” from 2009;

- “On the Energy Efficiency of Buildings” from 2017;

In framework of this analysis, special attention is paid on normative framework regarding energy efficiency including the usage of alternative energy sources. The main points of these legislation documents are the following:

Law of Ukraine *"On Energy Saving"* No. 74 / 943VR dated July 1, 1994. The law defines the legal, economic, social and environmental bases of energy conservation for all enterprises, associations and organizations located on the territory of Ukraine, as well as for citizens. The main principles of state policy in the sphere of energy saving The Law determines, in particular, the creation of the state economic and legal conditions for the interest in energy conservation of legal entities and individuals, the implementation of state regulation of energy saving activities based on the application of economic, regulatory and technical measures of management, priority of energy conservation requirements during implementation economic, managerial or other activities related to extraction, processing, transportation, storage, production and use of energy resources, the creation of energy-efficient material production structure based on the complex issues of economy and energy efficiency, taking into account environmental requirements, the widespread introduction of new energy saving technologies.

Law of Ukraine *"On Heat Supply"* No. 26333IV dated June 2, 2005. The law defines the basic legal, economic and organizational principles of activity at the objects of the heat supply sector and regulates relations related to the production, transportation, supply and use of heat energy in order to ensure Ukraine's energy security, increase energy efficiency of the functioning of heat supply systems, create and improve the market heat energy and protection of the rights of consumers and workers in the field of heat supply. The main directions of the development of heat supply systems in accordance with the Law are the planning of heat supply, the development and implementation of heat supply schemes of cities and other settlements of Ukraine, which should be at least 5-7 years on the basis of an optimal combination of centralized and autonomous heat supply systems, the introduction of cogeneration units, including on the basis of existing heating boilers, the use of non-traditional and renewable energy sources, including solar, wind, biogas, geothermal waters, waste production; reduction of losses during the transportation of thermal energy in main and local (distribution) heat networks through the introduction of modern types of thermal insulation.

Law of Ukraine *"On Alternative Types of Liquid and Gas Fuel"* No. 13913XIV of January 14, 2000. The law defines the legal, social, economic, environmental and organizational principles of production (extraction) and the use of alternative fuels, and also encourages an increase in their share of use up to 20% of the total fuel consumption in Ukraine by 2020.

The main principles of state policy in the field of alternative fuels The Law defines as follows: the promotion of the development and rational use of non-traditional sources and types of energy raw materials for the production (production) of alternative fuels with a view to saving fuel and energy resources, and reducing Ukraine's dependence on their imports, gradually increasing the regulatory share the production and use of biofuels and blended motor fuels, reducing the negative impact on the state of the environment through the use of for raw materials for the production of alternative fuels waste of various kinds of activity, adherence to environmental safety of production (production), transportation, storage and use of alternative fuels. According to the Law, alternative types of liquid fuels include combustible liquids derived from the processing of solid fuels (coal, peat, shale), alcohols (bioethanol, biobutanol) and derived synthetic products that can be used as fuel or fuel components (additives based on bioethanol and biobutanol); oils, other types of liquid fuels from biomass (including biodiesel); combustible liquids derived from industrial waste, including gas emissions, sewage, pouring and other industrial waste; fuel derived from oil and gas condensate of oil, gas and gas condensate fields of non-industrial value and exhausted deposits of heavy grades of oil and natural bitumen, if this fuel does not belong to the traditional type.

The Law of Ukraine *"On Alternative Energy Sources"* from 2003 defines the legal, economic, environmental and organizational principles for the use of alternative energy sources and facilitates their expansion in the fuel and energy complex.

As envisaged by the Law, the main principles of the state policy in the field of alternative energy sources are increasing the volume of production and consumption of energy produced from alternative sources for the purpose of economical spending of traditional fuel and energy resources and reducing Ukraine's dependence on their imports by restructuring production and rational energy consumption by increasing the share of energy produced from alternative sources, the observance of environmental safety by reducing the negative impact on the environment during the creation and

operation of objects of alternative energy, as well as in the transmission, transportation, supply, storage and consumption of energy produced from alternative sources, the safety of human health at objects of alternative energy at all stages of production, and also during transmission, transportation, supply, storage and consumption of energy produced from alternative sources.

Despite the list of Laws, in Ukraine in the field of energy, a number of decrees, orders, clarifications and additions to the laws are into force. They are additions to the Laws and are aimed to the efficiency of energy legislation in Ukraine.

The important part of Ukrainian policy in the field of energy is its international cooperation. On February 1, 2011 Ukraine received the status of the South East Europe Energy Community. The Protocol on Ukraine's accession to the Treaty establishing the Energy Community was signed on 24 September 2010 in Skopje (Macedonia) and ratified by the Law of Ukraine "On the ratification of the Protocol on Ukraine's accession to the Treaty establishing the Energy Community" dated December 15, 2010 number 2787-VI.

Participation in the Energy Community gives Ukraine the opportunity to introduce more competition in the domestic market, European technical standards and transparent rules of regulation, and a better investment climate. It also means deeper integration of the Ukrainian energy sector into the markets of the member states, strengthening of its own energy security. The benefits of membership in this organization are also additional opportunities for member countries in attracting international loans and technical assistance.

For the implementation of the Decision of the Council of Ministers of the Energy Community "On the implementation of Directive 2009/28 / EU and the amendment of Article 20 of the Treaty establishing the Energy Community", which establishes mandatory national renewable energy targets, in particular to provide certain guarantees to investors and encourage the development of the latest technologies and innovations in this field. Ukraine has committed itself to reach 11% of the energy produced from renewable energy sources in the country's total final energy consumption by 2020, which will be a powerful incentive for the further development of the use of renewable energy sources in Ukraine.

In order to achieve these goals, the Cabinet of Ministers of Ukraine on September 3, 2014, approved the Action Plan for the implementation of the Directive 2009/28 / EU of the European Parliament and of the Council and the Decree No. 902-r

from October 1, 2014 approved the National Renewable Energy Action Plan for the period by 2020.

Implementation in Ukraine of the measures provided for by the Directive 2009/28/EU of the European Parliament and of the Council on the promotion of energy produced from renewable energy sources will contribute to the implementation of the state policy on renewable energy development and will significantly reduce the consumption of traditional fuel and energy resources in all sectors national economy of Ukraine and, accordingly, increase the level of energy security of the state.

The National Renewable Energy Action Plan for the period up to 2020 provides for:

- increasing the installed electric power capacity of renewable energy to 10,900 MWh and bring the production of “green” electricity to 26 billion kWh in 2020;
- increasing the use of thermal energy produced from renewable sources to 5850000. toe in 2020;
- increasing the use of renewable energy in the transport sector to 505 thousand toes.

Ukraine implements active international cooperation. Nowadays, general foreign agency partners of the state are the following: European Commission (EC), Organization for Economic Cooperation and Development (OECD), International Renewable Energy Agency (IRENA), Austrian Energy Agency (AEA), International Energy Agency (IEA), German government company Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Center for Renewable Energy in the Hellenic Republic (CRES), Secretariat of the Energy Charter, Swedish Energy Agency (Energimyndigheten), German Energy Agency (DENA), French Agency for Environment and Energy Management (ADEME), Slovak Innovation Energy Agency (CIEA), United States Agency for International Development (USAID) - USAID Project "Municipal Energy Reform in Ukraine".

According to IRENA's experts, in 2030, the share of renewable energy in the final energy consumption of the country could be at least 21%. This objective also corresponds to the calculations conducted by the experts of the State Department of Energy Efficiency and representatives of the expert environment. Experts predict that 72% of renewable energy will be used for heat generation, 20% for electricity

generation, and 8% for the transport sector. The most promising direction of renewable energy will be the development of bioenergy.

ANALYSIS OF THE MARKET OF ENERGY-EFFICIENT TECHNOLOGIES

In Ukraine, housing and communal services, including housing, heat supply, water supply, drainage, improvement, etc., unfortunately, are characterized by outdated equipment, inefficiency of management, inability to timely prevent problems and a non-system approach to their solution. Two thirds of housing in Ukraine was built up to 70 years of the last century. More than a third of dwelling houses need major repairs. Imported expensive natural gas is used with low efficiency. Communal infrastructure is worn by more than 60%. The fifth part of the heating networks is in an emergency.

Housing and communal sphere of Ukraine is today the only branch of the national economy, which was not affected by market transformations. It works for the worst examples of Soviet times. Unfavourable economic and institutional conditions for functioning of the housing and communal services sector of Ukraine, administrative intervention in pricing and lack of strong political will to carry out structural reforms in this sector significantly reduce its efficiency. The term "communal infrastructure" describes the complex of technical means necessary to provide the city's main services. The infrastructure includes water supply and sewage systems, waste water treatment plants, energy, heat and gas supply systems, roads, communication systems and public transport. The cost of maintenance and the desire to improve the quality of utilities provided to the population, require serious investment, new approaches to self-organization of the population and a higher level of organizational management.

The largest sectors of the communal infrastructure that require full-scale modernization with the use of the best technologies are:

1. Heat supply (in particular, production of thermal energy);
2. Water supply and sewage (together with treatment facilities);
3. Public transport;
4. Exterior lighting;
5. Handling solid household waste.

On this basis, the Government of Ukraine has declared its priority to gradually carry out the reform of housing and communal services, in particular, bringing prices of basic utilities, mainly of heat and electricity, to market, which will lead to competition, as well as increase of efficiency of energy consumption and development of renewable sources energy, etc. These measures are aimed at improving the

investment attractiveness of Ukraine's housing and utilities sector and attracting resources to invest in the latest energy-efficient and environmental technologies.

BUILDING SCALE (ENERGY EFFICIENCY)

Building shell improvement

External walls are an essential element of houses, which not only perform the carrier function, but also protect the internal space of the house from environmental exposure. Modern building structures, made with modern technologies, allow to save on the heating of houses and to rationally use energy carriers. But in buildings built during the Soviet era, which have traditional designs, and most often built of brick or panel blocks, heat insulation is used to save heat. In Ukraine, among residential houses, industrial premises, as well as buildings of communal property, external insulation of facades is most often used for insulation.

But, for thermal insulation of buildings of historical value, there are many restrictions. The legislation does not allow to change the design of the building and its facades. In this way, the methods of energy effective reconstructions are rather limited. The standards and requirements applicable to the new building cannot be applied to the historic one. Historical architectural designs and materials react sensitively to modern materials, installation of new heating systems, isolation and sealants. In buildings with historic facades and architectural elements, the external side could be warmed up only with the help of wet facade installation or facade plaster, so an alternative option is insulation of the inner side of the outer walls, which is technically more complex technology.

1. Thermal insulation of the walls

Thermal insulation is a method of preventing or reducing the transfer of heat from one body to another through the use of a material with low thermal conductivity. In addition, this term may refer to structural elements or the materials themselves, reducing the process of heat transfer, as well as activities for the arrangement of these materials.

Thermal insulating materials have a small degree of thermal conductivity, as a rule, the coefficient of thermal conductivity is not more than 0.2 W/(m•K)). Moreover, high-quality thermal insulation is characterized by high porosity (70-98%), insignificant volumetric mass and erosion-resistance, achieved due to high compressive strength of 0.05-2.5 MN/m^2.

From the position of thermal physics, it is most efficient to apply thermal insulation outside the building, as in this case the supporting structure of the wall is always in the zone of positive temperatures and optimum humidity. Such way of thermo-isolation is implemented by facade plaster by simple and wet methods. However, sometimes thermal insulation inside the building is also performed. But with this option it is necessary to carry out a calculation based on the humidity conditions for the need for a vapor barrier and only in exceptional cases, when it is impossible to change the facade of the building for one reason or another.

The following types of thermal insulation materials are traditionally used for wall insulation: expanded polystyrene, mineral wool, polyurethane foam, warm plaster, foiled polyethylene, liquid thermal insulation on the basis of ceramics, thermo-paint. In historic buildings, if the method of outside thermo-isolation is chosen, such materials like mineral wool and plaster are used frequently.

Thermal insulation of external walls is performed mainly in the following ways:

- facing and warming of a facade with decorative plaster;

The application of facade plaster improves the appearance of the building, and enhances the insulating properties of previous materials. Plastering facades on insulation is most often carried out on a reinforcing mesh. Such insulation of the facade retains heat and gives the building the following quality characteristics:

- strength;
- moisture resistance;
- vapor permeability;
- resistance to temperature differences.

For painting the facade, the following colours are used:

- acrylic, on the basis of acrylic resins, universal application;
- silicate, having organic additives and silicate glass;
- silicone, in essence - dispersion of an artificial resin;
- mineral, based on cement and lime;
- silicone modified (acrylic).

- insulation of external walls using the wet facade method;

Basically, using this method, mineral wool is used as a material for thermal insulation. The main features of mineral wool are as follows:

a) Shrinkage of mineral wool is extremely small (fractions of a percent);
b) Thermal conductivity is inferior only to materials from expanded polystyrene;
c) Water absorption Hydrophobic wool has an index of 6-30% with full immersion in water. The moisture content of the dry material is 1%.
d) Fire resistance. The material is non-flammable and is used to isolate surfaces with temperatures up to + 400 °C.
e) Soundproofing. Insulation is used as sound insulation. The sound absorption coefficient of special acoustic mineral wool slabs is 0.7 - 0.9.
f) Toxicity. The results of recent studies show that this material is harmless to humans.
g) Service life - 50 years.

Restoration of walls with a wet method involves the application of several layers of insulation with finishing plastering. Features of the application may vary slightly depending on the type of insulation and wall material, but there are general steps:

a) Fixing insulation;
b) Drawing the reinforcing grid;
c) Putting plaster;
d) Finishing decoration with plaster followed by painting.

In historic buildings very often with wall insulation carried out restoration works. During restoration, such works as plastering of facade cracks, plastering with solutions of a specially selected composition, painting the facade with a non-aggressive, resistant painting composition, renovation of frescoes, stucco, gilding; repair of vertical ribs for wall support are performed. It should be noted, that the main purpose of the restoration of the monument is to preserve historical authenticity. Thus, in the course of modernization, monuments of architecture are guided by the following principles as the principle of least intervention and change, ensuring maximum preservation of the authenticity of the monument; and the principle of reversibility, that is, all materials and technologies used should be as reverse as possible (to be removed without damaging the authentic material). It is forbidden to change the principal structure of the sights and decor of buildings. Changes to the layout of the object or its individual premises should be determined only by the justified extreme necessity of exploitation and saving. The saving of the monument should provide for the preservation of a safe, traditional environment at the same time. Around the object (structure), monuments need to create a security zone in which new construction, all demolition and

transformation, which could change the ratio of volumes and colours, are prohibited. When performing conservation and restoration works, traditional for the monument technologies and materials should be used, as well as materials that have been developed and tested by practice are specially designed for restoration work and are made according to the existing regulatory documentation. If the use of traditional equipment (materials and technologies) is impossible or does not give the desired result, the conservation or restoration of the monument can be done using modern conservation and construction techniques, the effectiveness of which is proved by scientific data and guaranteed by practical experience and does not harm the authenticity of the monument.

It should also be noted that the materials for restoration works on the architectural monument should by nature be similar to authentic materials, their physical and technological characteristics are represented by the technological part of the project for restoration. Replacement of these materials by others is allowed only upon written agreement with the customer and the developer of the technological part of the project and the chief architect of the project.

2. Base wall weatherization.

The environmental impact greatly falls on plinth wall part of the building, e.g. temperature drops, precipitation, etc. That is why the plinth walls are recommended to properly and efficiently weatherize. This will allow, in addition to direct protection from cold, to improve waterproofing, as well as reduce the risk of dew point and condensation in the underground part of the building. If the plinth walls are properly weatherized, the life cycle of the building will be increased by several decades.

In case of salinization of masonry and raised moisture of the base wall (humidity higher than 8%) during restoration, it is recommended to use sanitary plaster, which has high vapor permeability, porosity (not less than 25%) and the ability to accumulate salt. Stuccoing with dense cement solutions of monuments, for the construction of which no cement was used, is strictly prohibited, and the facing of the cap dense rocks are allowed only provided the installation of reliable systems that do not allow the walls to soften (waterproofing, drainage, etc.).

3. Energy efficient windows.

One of the main building materials in historical buildings is wood, from which various constructional and decorative details are made. Mostly in historic buildings

there are wooden windows. Preservation of historic wood and characteristic wooden parts is one of the main tasks in conservation and restoration of the monument and includes a complex of measures that restore the structural strength of wood, protect it from biological and atmospheric damage, excessive moisture and fire. However, if the condition of the wood is unsatisfactory and damage requires replacement, according to the standards, removal and replacement of damaged wood is possible. In the case where the overall appearance and shape of the parts are preserved, this should be taken into account when manufacturing a new part. Thus, in buildings, in order to improve energy efficiency, if the condition of the windows is unsatisfactory and cannot be restored, they are replaced with new ones from this material in accordance with all norms and quality standards.

Coniferous wood, oak and ash, as well as glued squared blanks for window blocks are used for the manufacture of window blocks. Allowed to use solid, resistant to decay of tropical woods. The moisture content of the wood should be in the range of 8 to 14%, depending on the paintwork and adhesive materials used in the technology of manufacturing. The regulatory moisture content of wood is set in the process documentation, and the range of humidity values should be within 3% (for example, 8-11%).

The constructive solution of window units should provide for the possibility of airing the premises with the help of vents, transoms, sashes with tilt-and-tilt (tilting) adjustable opening, valve sashes or ventilation valves. Recommended use in the design of products of devices for regulating the temperature and humidity conditions: climate valves and self-ventilation systems.

Double-glazed windows should be installed on linings. The design (fastening) of the lining should not allow the possibility of their displacement during operation. Silicone sealants or elastic polymeric sealing gaskets or combinations of these materials should be used to install double-glazed windows.

Moreover, one of the most important points in energy efficiency of the windows is the type of glass unites. There are the following:

a) Low emission K-glass. At the stage of manufacture, a layer of indium and tin oxides is applied to the surface of ordinary float glass. As a result of chemical interaction, a thin and resistant metal oxide film is obtained. The coating has sufficient strength, it is difficult to scratch or damage it by other mechanical means. To improve

performance, the material is hardened and laminated. There are no special requirements for the storage and transportation of glass with a "solid" K-coating. This type of material is one of the first developments in this direction. Products are much inferior in their characteristics to the next generation products. According to the manufacturers, the use of K-glass as a part of a glass unit reduces the heat loss from a room during the cold season only by 30%.

b) I-glass. A two-layer coating of silver and titanium oxide is deposited on one surface of the glass by cathode sputtering. I-glass is more efficient - it reflects back into the room about 90% of the infrared energy emitted by household appliances. The main disadvantage is low resistance to mechanical and chemical influences. The coating is easily scratched and oxidized upon contact with air. Therefore, the coated side of the glass unit should be turned inside the structure to prevent damage. To exclude oxidation in the premium segment products, the space between the glasses is filled with inert gases. This solution further improves the sound insulation and heat insulation characteristics of the structure. Often, argon acts as an inert gas.

c) IM glass. The use of multifunctional (IM) glass in a window construction is the most modern and innovative solution. Multilayer sputtering is applied on the base:

- the middle functional layer of silver or chromium, reflecting infrared light waves;
- protective layers - to prevent damage to the main "soft" layer;
- the lower and upper layers of oxide and nitrite. Determine the secularity, light transmission properties and colour of the product.

The technology allowed to embody in one material the advantages of all existing types of glass: energy-saving, tinted, shock-proof, self-cleaning.

So, in historic buildings there are several ways to introduce energy-efficient windows. The choice must be provided by specialists and supported by performed analysis as well as all necessary documentation.

4. Roof weatherization.

Restoration of the roof is a particularly important aspect in preserving the monument - the general condition of the monument depends on the quality of the works when it executed. In the project of restoration and technological scheme of works on the monument repair and restoration work on the roof should be considered one of the first. The roof and its functional and decorative elements are important in determining the general historical character of the building. This includes forms of roofing: domes,

gates, chimneys, gutters; Roofing material: wood, tile, metal, as well as their dimensions, colour, design. It is necessary to restore the roof by maximally preserving the authentic (historical) roofing material, its forms, functional and decorative elements, which is important in determining the historical nature of the building. It is not allowed to radically change the roof of the monument. It is not allowed to remove the main parts of the roof or roofing material that can be restored or repaired. It is allowed to make certain changes and additions related to the new use of the construction so that they do not change the historical nature of the building and do not harm the characteristic details of the monument. The decisions taken must be agreed upon and approved in accordance with the established procedure. The mechanical and service equipment, if required and provided by the project, shall be installed in such a way that it is invisible and does not affect the historic roof view. It is not recommended to paint or apply other decorative coatings on roofing material, which has historically been unpainted. Thus, in case of necessity to carry out works on energy efficiency (roof insulation), it is necessary to take into account all the above-mentioned provisions.

Works on repair, restoration and rehabilitation of structures of roofs and roofs of monuments themselves should be carried out only if there is an object approved by the established order of the project of roof restoration and technological schemes. The most popular materials for roof insulation are the following: slag wool, fibre glass, foam cellular plastic, polyurethane foam, expanded polystyrene. It is important, that the choice of material for the construction of the roof and the cover must be substantiated in the design of roof restoration, along with the definition of optimal methods for the implementation of roofing works on the monument, with the preservation or restoration of historic forms of roofs and the use of historical or adequate materials.

ROOF INSULATION TECHNOLOGY

There are two types of roof insulation: external and internal. External insulation involves laying the material during the installation of the roof, internal - thermal insulation on the inside of the placement. Thermal insulation, as a rule, is carried out in one of two types. The first one involves placing the material on the raft system from the outside or inside; The second one involves laying the heater in the space formed by

the rafters. This method allows quickly warming the room, keeping heat for a longer time.

There are differences in roof insulation technology depending on its type. In the case of cattle roofing, first of all it is necessary to equip the waterproofing layer. This layer is placed between the roof system and the roof, its main task is to protect the room from moisture penetration. The water insulator must be laid on the truss system, strengthened with nails or a construction stapler. After the waterproofing layer is laid, one should proceed to the insulation work of the roof. As a rule, for this any rolled or tiled insulation made of mineral material is used. Its installation should be made in the direction of the bottom up, that is, from the floor to move towards the ridge. Insulation should have a width equal to the space formed by the adjacent rafters. Insulation is strengthened with a construction stapler or slats. The material should have a thickness of at least 10 cm. The next layer will become a vapor barrier, it should be strengthened to the rafters. The material is strengthened as in the previous layers.

The roof of the attic will have a slightly different thermal insulation device, in this case the sequence of layers will be different. So, as the first layer will be the ceiling lining, it uses a board or plywood. A vapor barrier is laid over the skin. Then a layer of insulation is laid, and a membrane is placed on top of it, which acts as a vapor barrier.

In the case of a flat roof, the sequence of insulation is important. Before one starts external insulation should the surface carefully rid of debris and dirt. Next, the base, whether it is made of concrete or wood, is covered with insulating plates, gluing them. An additional vapor barrier is often laid under them. Glue or mastic can be used as a material for fastening. It is recommended to lay a couple of layers of insulating material with overlapping seams, placing the sheets in a checkerboard pattern. Next, the waterproofing layer is laid; for this, a tie is used, the thickness of which can be approximately equal to 5 cm. A waterproofing roll material is rolled out from above. Overlap adjacent sheets for tightness should be approximately 15 centimeters. The surface is eventually covered with a layer of roll waterproofing.

Thus, the insulation of the roof of a historic building can occur by various techniques. However, it is necessary to take into account standards and legislation that regulate the procedure, use of materials and other aspects of the reconstruction of a historic building. In this way, e.g. according to the Law of Ukraine, “On the Protection

of Cultural Heritage" and DBN V.3.2-1-2004 "Restoration, conservation and repair work on monuments of cultural heritage", it is possible to carry out restoration work only with the appropriate permission from state bodies who are authorized to monitor the safety of the building and are responsible for non-compliance with the law. The used materials should correspond as much as possible to the original, and any changes in the appearance of the building will be allowed only if the activity is necessary to protect the building from destruction.

Natural cooling techniques

Natural cooling in buildings is done by ventilation and air conditioning. According to DSTU 2388-94, ventilation refers to the creation of an air exchange in a room to remove excess heat, moisture, harmful and other substances in order to ensure acceptable meteorological, sanitary and technological conditions of the air environment. Natural ventilation, in turn, is influenced by the pressure difference caused by the thermal and (or) wind pressure. It should be noted that in historic buildings, the average air temperature is low enough due to construction materials, the most common of which were brick and concrete during construction, which maintain the air temperature in winter and, in the summer, keep cool. However, the northern part of Ukraine in the summer is characterized by a very high air temperature, which in turn requires cooling of buildings.

A natural ventilation system exists in every premise. It is carried out due to the leakage in the construction of buildings, by the ordinary ventilation of the rooms, or by the installation of special inflow and exhaust devices, the air exchange in which can be regulated. The principle of operation of natural ventilation is due to

- temperature difference between ambient and room air;
- pressure difference of the "air column" between the lower and upper levels;
- as a result of "wind" pressure.

The operation of natural ventilation depends on variables such as air temperature or direction and wind speed.

In the past, architects did not have high-performance engineering systems, but had in their arsenal a number of natural thermal insulation solutions by which they were able to make objects comfortable. Thus, galleries, window shutters were built earlier, and deciduous trees were always planted around the building. Moreover, for the

construction of buildings, the optimum sites were selected, taking into account the direction of winds, the level of groundwater, the intensity of sunlight, the presence of vegetation and the nature of the landscape.

For example, in cold climates, buildings were designed in such way that the main source of heat was in the centre. The premises themselves have always been compact with a minimum glazing area. The hot and humid climate provided for the construction of maximum open spaces, which had to be through ventilation. Often resorted to the construction of a dome that performs the function of the hood. Houses of the second type are prevalent in the southern part of Ukraine. In addition to the above-mentioned methods of natural cooling, ventilation shafts are often used in buildings to remove CO_2, which are currently in a state of emergency.

To improve natural cooling (ventilation of historic buildings), the most common among natural methods is the use of wind-driven natural ventilation. This is one of the widely known and used methods of intensification of air exchange. Wind prompting is the use of wind energy to eject exhaust air from ventilation ducts. The deflectors used here have been used since the mid-19th century on buildings and vehicles, and have been tested in the field and in wind tunnels. Static deflectors are now used as devices for the ejection of air from individual and collective channels of natural ventilation, individual and collective chimneys, exhaust ducts of gas combustion products. They are used on buildings of any surface. The principle of the deflector is based on the use of the Bernoulli effect: the higher the flow rate when changing the cross-section of the channel, the less the static pressure is in this section.

Natural lighting techniques

Natural light throughout history has defined the nature of the perception of architecture, emphasized, thanks to light and colour, the tectonics of buildings and influenced the perception of form. Questions about the use of natural light are always relevant in architecture. Skilful use of light can focus on the elements and details of the building, emphasizing their importance, sharpen the contours of the form, detect the texture of the material, and vice versa - to visually "destroy" the architectonics of the building, diminish the perception of the interior due to the sharp contrast of light in the field of view. Not only the intensity of light is important, but also the way in which natural light enters the space of a building. The nature of light penetration and

the dominant vector create the desired perception and the atmosphere required for the purpose of the room. Therefore, interior lighting is one of the elements of the architectural decision to combine the areas of decorative, artistic and utilitarian lighting.

Natural lighting is divided into three main types: side, top and combined ones (a combination of the first two). It is characterized by a high level of illumination (thousands of lux) a gradual decrease in brightness in the field of view from top to bottom; the combined action of the sun and sky (directed and diffused light) by one-sided shadows; “Daytime” radiation spectrum; dynamics of intensity and spectrum. Natural light is characterized by the following features:

- distribute the brightness in a certain order in the field of view;
- distribute illumination (brightness) evenly on flat surfaces and unevenly on curved surfaces;
- to be created by directional, scattered and reflected light in different proportions in different conditions;
- direct the light, allowing the architectural rhythm to accompany the rhythm of the light-shade;
- direct light from top to bottom;
- provide contrast of illumination influencing contrasts of colours;
- dynamics.

Light access to individual rooms and distribution in the interior space are determined by exact calculation, depending on the purpose of the room. For utilitarian purposes only, natural light in cultural buildings is not necessary. For example, in theatres, museums, galleries, performing arts venues, and more. Its utilitarian role is minimal, and the desired comfort of visual perception is achieved by means of artificial lighting. In some cultural objects, natural light is penetrated from all sides by the use of frame structures. This principle of the organization of the light environment has been implemented for decades in many projects. In many buildings, sunscreens have been used to improve the light comfort of the facades, and transparent glass has been replaced with matt, coloured or tinted windows. This led to the emergence of new light-shading effects and changed the compositional value of light. The tendency to use transparent facades in architecture has proven to be extremely robust. They are used everywhere, regardless of climatic conditions and purpose of the building. In many

modern buildings, transparent facades primarily illuminate the foyer, vertical communications, saloons, cafeterias, etc. Instead, the main rooms are "closed" for daylight.

The overhead lighting system provides great opportunities for maximum use of the inner surface of the blind walls of the building. Although there are a number of structures where such a system operates, it is most common in religious buildings. The light penetrating the temple mainly from above determines the parameters of space, establishes a hierarchy, subjugates the constituent elements, implements dynamics, creates an appropriate mood, and also introduces the visitor to the temple into an illusion state, enhancing aesthetic experiences and causing unexpected visual effects. In temple construction in Ukraine, spatial metal structures are often used with continuous glazing of the roof or walls, with natural light factors at the floor level of 5-7% or more, or the formation of the interior by a combination of complex planes of walls, ceiling and solid glass. However, in addition to the sphere of temple construction, natural overhead lighting is also used in other cultural and historical buildings, especially theatres and museums. The design of the ceilings through which light enters has great advantages (first of all, it allows to concentrate the light stream on a specific area), but they are uncontrolled.

The overhead lighting of museums provides uniform illumination of large exhibits. With proper design, there is no unwanted reflection of light. Also, window-free walls are used for exhibits, like backgrounds and the like. But the disadvantages of this type of lighting are the complexity of the design and operation. Sometimes, in the absence of natural light in the room, optical fibres are used. Such designs allow to transmit light and accumulate it. They can be designed in rooms where:

- there is no way to provide the proper level of natural light in another way (production and other premises);
- there is no daylight and windows design are not possible (basements, closed corridors, rooms without exterior walls, etc.);
- there is a significant lack of daylight or no electricity;
- in energy saving and other construction.

However, it should be noted that during the reconstruction or modernization of historical buildings, additional coordination is required and obtaining permission and establishing such structures in accordance with the legislation of the country.

The side lighting system provides a simple design solution and intensive illumination of the room, but there is a large imbalance in lighting, penetration of direct sunlight, and so on. The side lighting differs depending on the purpose of the building and the climate zone (window size, etc.).

Therefore, natural lighting has many advantages, energy efficiency and ease of use, but it is more difficult to control, it can cause unwanted glare, condensation and destruction. Therefore, it is important to modernize existing natural lighting and combine it with mechanical lighting.

Energy efficient heating and cooling systems

MINI HEAT STATION

The concept of "cogeneration" is not new to domestic energy. But previously these technologies were widely used, mainly in large steam turbine power plants. However, today, along with “big” energy, the role of small-scale energy objects: autonomous power plants based on gas heat engines with a range of single capacities of 400 - 4500 kW is becoming quite significant. Municipal water-heating boilers are successfully reconstructed into cogeneration power plants based on gas-piston engines, and factory steam boilers - in cogeneration gas-piston power centres.

Cogeneration is a joint process of production of electrical and thermal energy within one device - a cogeneration unit (mini CHP). A mechanical source of electricity generation is the primary drive that rotates the rotor of an electric generator: a gas piston engine, a gas or steam turbine. Thermal energy is produced by the utilization of heat losses (utilization of heat of coolant, lubricant, compressed gas-air mixture and gases) of the primary drive engine (gas-piston), gas turbine, diesel. The heat produced by cogeneration units is used for the production of hot water, steam, in refrigeration units, as well as in the technological processes of drying hot air.

In modern cogeneration units based on gas-piston engines, the utilization of the heat of combustion of the fuel reaches 85-90% and only 10% is lost. Fuel savings in the generation of energy in a cogeneration cycle can be as high as 40% compared to separate production of the same amount of electricity (condensing power plant) and thermal energy (boiler).

There are two main groups of cogeneration units:

1. Installations of simultaneous production of electric and thermal energy (foreign analogue: CHP);
2. Installations (power plants) of combined cycle with utilization boiler and steam turbine (foreign analogue: PCP). Most often, they are power plants with gas turbine, utilizer boiler and steam turbine (high-capacity steam and gas installations).

There are many arguments to date for the implementation of cogeneration technologies. Cogeneration units have the following features: cheap electricity and heat, proximity to the consumer, no need for expensive power lines and substations, environmental safety, mobility, ease of installation and many other factors.

Small energy is not only an alternative to a centralized system - it becomes the basis for the rapid development of newly developed areas, the opening of new industries and the expansion of existing ones. Very often, due to the deterioration of the equipment of the existing power grids, it is difficult to connect new industrial consumers, and sometimes it is simply not economically feasible (in case of a large removal of the consumer from the transmission line). As a result, the use of autonomous combined heat and power (cogeneration) generates a certain energy reserve in a centralized system.

The cogeneration market in Ukraine is in its infancy. The leading direction, where the first successes were noted, were mini-CHP plants installed for the needs of utility networks in some large cities, as well as projects implemented at enterprises of the national economy. Basically, these installations are currently being installed at industrial enterprises, but gradually the market is expanding to other housing and communal facilities.

Rational use of energy

HEATING AUTOMATION

Today in Ukraine, most historical and cultural buildings have outdated heating systems. Because of this, significant heat losses occur, which leads to inefficiency of the system as a whole, and significant monetary costs. Several technologies are still being used to rationalize energy use. The most popular is the establishment of an individual heat point. This device is designed to transport thermal energy from the heating network (CHP, central heating, boiler) to the house systems: heating, hot water, ventilation. The main component of this complex is the regulator of the thermal

power of the heating system according to weather conditions. An electronic temperature controller, using an electric control valve, adjusts the amount of coolant coming from the heating system to the building, reducing it to the required level. This allows to consume only the amount of heat necessary at a particular moment in time and thereby significantly save heat energy. However, it should be noted that engineering in general and engineering among communal and state-owned buildings are not yet widely used due to lack of funding.

LIGHTING AUTOMATION

For the most complete and accurate accounting of the presence of daylight, as well as taking into account the presence of people in the room, which is especially important in buildings of historical and cultural heritage (museums, theatres, etc.), automatic control tools are being introduced. Automated lighting control systems, which are intended for use in public buildings, perform the following functions typical of this type of product:

- accurate maintenance of artificial lighting in the room at a given level, which is achieved by introducing into the lighting control system a photocell located inside the room and controlling the illumination created by the lighting installation;
- taking into account the natural light in the room (this function can be carried out by the same photocell, and in the previous case, provided that it monitors the full (natural + artificial) illumination. In this case, energy savings can be 20 - 40%;
- accounting for the time of day and day of the week;
- accounting for the presence of people in the room.

As a rule, historical buildings are one- or two-storied buildings, so there may be no need for all the advantages of individual heating units, for example balancing risers. But when regulating the internal temperature depending on the external temperature, certain savings can be achieved with the help of sensors. Lighting automation is especially applicable in museums, where a large number of exhibits are illuminated, as well as in places where the presence of people is unstable. With motion sensors, a significant reduction in energy consumption can be achieved. But it is worth noting that such techniques are only beginning to be used on the Ukrainian market and have not yet received wide distribution.

RES (BUILDING SCALE)

Solar Energy Systems

Solar energy is one of the most affordable and promising renewable energy sources. Behind the National Renewable Energy Action Plan until 2020, the share of thermal energy production from solar energy should be 200 thousand tons of oil equivalent. The potential for the development of solar heat supply systems primarily depends on the level of solar radiation and the number of sunny days in the region. For Ukraine, the average annual solar radiation varies from 800 to 1400 kWh /m^2 depending on the region. The highest level of solar radiation in Odesa, Kherson, Mykolaiv, Zaporizhzhia, Donetsk regions and Crimea (now annexed). Therefore, in these regions one can achieve high levels of production capacity of solar collectors, also taking into account their own efficiency.

Taking into account the climatic peculiarities of the territory of Ukraine and the presence of powerful enterprises (including manufacturers of semiconductor materials, as well as microelectronic and electrotechnical devices, which makes it possible to make additional profit in the production of electricity using photovoltaic technologies), the conversion of solar energy to the production of electricity using photovoltaic electricity devices, is one of the most promising areas for the development of renewable energy in Ukraine. The most widespread technologies of production of photocells are shown in fig. 1.

Production of single crystalline photocells is carried out using the Choralskyi method. In order to obtain a silicon single crystal, the initial crystal is immersed in the melt of silicon with boron and gradually raised several meters above the surface of the solution, while the solution is crystallized. From the obtained single crystalline work piece cut off the edges to obtain square elements and cut it into elements with a thickness of about 0.3 mm. Then the elements are doped with phosphorus to add n-conductivity and create a pn-junction, polished, applied anti-reflective coatings and conductive paths and we get ready-to-use single-crystal photocell.

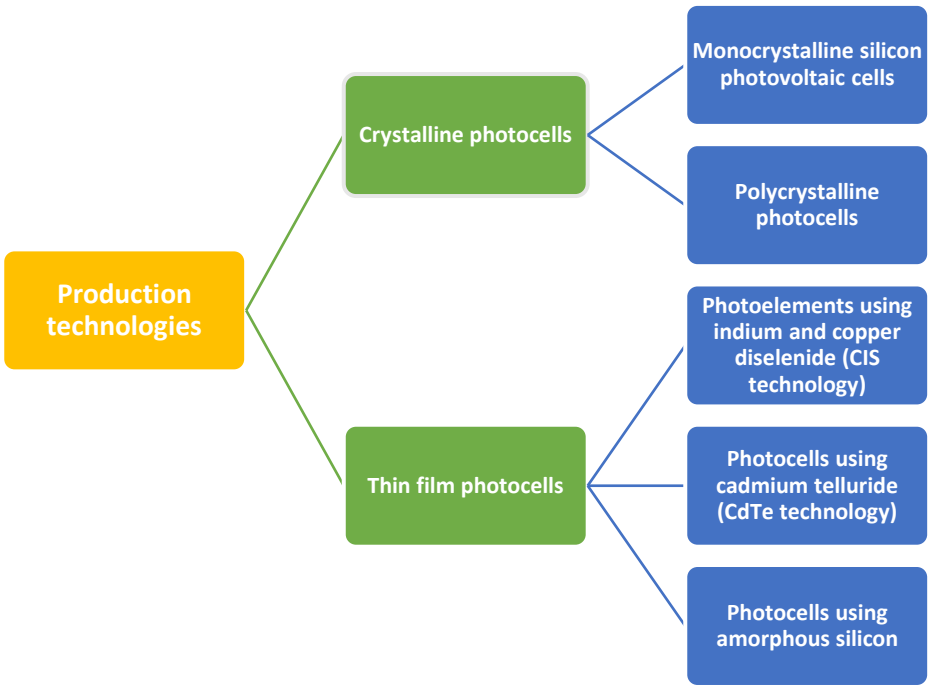

Figure 1. Technologies for the production of solar panels in Ukraine

The main characteristics of panels with this technology are the following:

- efficiency from 15 to 18 percent;
- square or square shape with rounded or cut corners;
- thickness 0,2 - 0,3mm;
- colour from dark blue to black with anti-reflective coating or grey uncoated;
- appearance - homogeneous.

Polycrystalline solar cells are produced using uniform directed cooling of a vessel with molten silicon and boron. At the same time, unidirectional homogeneous crystals are formed in the container from a few mm to several cm in size. The resulting block of polycrystals is processed in the same way as a single-crystal work piece. The main characteristics of the panels with this technology are as follows.

- efficiency from 13 to 16 percent;
- square shape;
- thickness 0.24 - 0.3 mm;
- colour blue with anti-reflective coating, silver grey uncoated;
- appearance - a block of crystals of different directions, some crystals are clearly visible on the cut.

The active semiconductor material in CIS photocells is indium and copper dyslenide. CIS compounds are often doped with gallium and / or sulphur. In the

production of the element, the glass is coated with a layer of molybdenum to conduct electric current, for the photocell, this layer will be the cathode. The CIS compound layer in the photocell has p-conductivity and is applied to the molybdenum layer. Zinc oxide with an admixture of aluminium ZnO: Al is used as a transparent conductor of electricity anode. This layer has n-type conductivity and an auxiliary layer of zinc oxide i-ZnO is sprayed in it. The intermediate layer of cadmium sulphide CdS is used to reduce losses associated with the lattice mismatch between the CIS and ZnO layers. The main characteristics of the panels with this technology are as follows:

- efficiency from 9 to 11 percent;
- the shape of the element corresponds to the shape of the module;
- thickness of the module in non-toughened glass from 2 to 4 mm;
- colour from dark grey to black;
- appearance - homogeneous.

Cadmium telluride solar cells are produced on a substrate with a transparent TCO conductor, which is made of indium oxide and ITO tin and is used as a front contact. This lining is coated with a layer of cadmium selenide CdS with n-type conductivity. After that, an absorbing layer of cadmium telluride CdTe with p-type conductivity is applied. After that, the module is closed with a metal conductive plate. The main characteristics of the panels with this technology are as follows:

- efficiency 8.5%;
- the shape of the element corresponds to the shape of the module;
- module thickness in non-toughened glass - 3mm;
- colour from mirror dark green to black;
- appearance - homogeneous.

Amorphous silicon in solar cells does not form a homogeneous structure, but forms a random network. As a result, hydrogen is absorbed through the open boundaries of the crystals. This confectionery amorphous a - Si: H silicon is created in the plasma reactor from the gas phase of silicon hydride SiH_4. Doping of silicon is carried out by mixing gases containing an alloying element - boron hydride $B2H_6$ for p-conductivity and phosphorus hydride PH_3 for n-conductivity. Due to the small penetration distance of the dopants in amorphous silicon, the life of the charge carriers is not very long; therefore, additional layers with n and p conductivity are deposited on the silicon layer. A transparent TCO conductor with tin oxide SnO_2, indium oxide and tin oxide ITO or zinc

oxide ZnO is used as the front contact. A metal conductive plate is used as the rear contact. The main characteristics of the panels with this technology are as follows:

- efficiency from 5 to 7 percent;
- the shape corresponds to the shape of the module, the maximum size is 2 × 3 m;
- the thickness of the element in non-tempered glass is from 1 to 3 mm;
- colour from brown to blue or purple;
- appearance - homogeneous.

Solar thermal/PV systems

Solar heating systems (SHS) are used to produce thermal energy for small local and individual heating systems at facilities in the private and housing sector. SHSs can be used seasonally and year-round. For autonomous heat, SHS requires additional capacities for heat production to satisfy all consumer needs during periods of lack of solar radiation or winter. SHS consists of the following components: solar collectors; regulator; a storage tank, an expansion tank, a workstation, a heat exchanger, a heater, for example, a heat electric heater (HEH) or other source of energy production. Various placement options and types of equipment can be applied: various types of collectors and their placement (on the roof, on the ground, on the walls of the building), various storage tanks (most often these are ordinary water tanks). There are also various combinations of SHSs with other additional sources of energy production, for example a combination with a system operating on heat from waste incineration and industrial processes; combination with geothermal heat; Combination with heat pump; Combination of biofuel boiler house. Three types of solar collectors are distinguished (fig. 2).

The flat collector consists of an element that absorbs solar radiation, a transparent coating and a thermally insulating layer. The absorbing element is called an absorbent; it is connected to a heat-conducting system. The transparent element is usually made of tempered glass with low metal content.

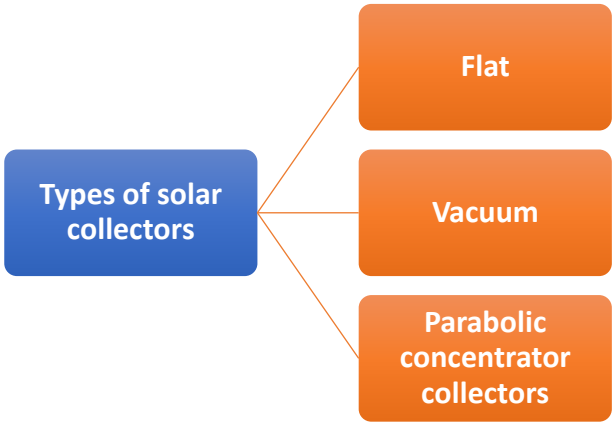

Fig. 2. Types of solar collectors

In the absence of heat extraction, flat collectors are capable of heating water to 190-200 ° C. The more radiation energy is transferred to the heat carrier flowing in the collector, the higher is its efficiency. The efficiency of the collector can be increased by using a special optical coating that does not emit heat in the infrared spectrum. The standard way to increase collector efficiency is to use an absorbent from sheet copper because of its high thermal conductivity. Among the main advantages of such collectors should be highlighted the next: their versatility and ease of use; simple installation and maintenance; fairly low cost (up to 500 $ / m^2). However, they are maximally effective only in the summer period of time, and their heat loss to the environment is significantly high.

The vacuum collector raises the temperature of the heat carrier to 250-300 ° C in the mode of limiting heat removal. This is achieved by reducing heat loss as a result of using a multilayer glass coating, sealing or creating a vacuum in the collectors. The system with vacuum manifolds, unlike flat ones, is able to work efficiently all year round. The outer part of the tube is transparent, and a highly selective coating is applied to the inner tube that captures and concentrates solar energy.

There is a vacuum between the outer and inner tubes. It is the vacuum layer, as a heat insulator, that makes it possible to save about 95% of the captured thermal energy. The tubes are of the following types: coaxial tubes of direct heating, U type tubes, tubes with the Heat Pipe system (collectors with such tubes are the most popular on the market). The main advantages of this type of collectors are high reliability; maintaining high performance in winter due to thermal insulation; ease of installation; high thermal insulation properties of the heat sink, etc.

Parabolic collector-concentrator. An increase in the operating temperatures of the heat carrier in 120-250 ° C is possible by introducing concentrators into the solar collectors using parabolic cylindrical reflectors laid under the absorbing elements. These systems can generate high temperatures and are mainly used for energy production in regions with a high level of direct solar radiation, so in Ukraine they have not received widespread use. Higher operating temperatures require sun tracking devices. They are most effective because they use different types of mirrors.

Today in the Ukrainian market there is a fairly wide selection of different solar collectors from various manufacturers and technical specifications. The most popular vacuum manifolds are coaxial vacuum tubes with a heat-pipe system. The market presents products of both foreign and domestic manufacturers. Among foreign manufacturers there are such manufacturers like: Altek; German - Viessmann, Vaillant, Bosch, Buderus, Solvis, Polish - Hewalex; Greek - Sunrise; Australian - Apricus Italian - Immergas; among domestic are the following: Atmosfera, Progress-XXI, Krasilov Aggregate Plant (produces Cordy solar systems). It should be noted that the main consumers are industrial enterprises, however, the private and utilities sector is gradually increasing its market share.

Small scale building-mounted wind turbines

According to the NKREKP, as of early 2019, Ukraine has installed 2,117 MW of green electricity generation capacity, including 533 MW of wind generation. Ukraine has a high wind potential of almost 50% of its territory. Wind turbines are one of the most technologically advanced and efficient alternative energy sources. The most attractive regions for the use of wind energy are the coasts of the Black and Azov seas, mountainous areas temporarily annexed Autonomous Republic of Crimea, the territory of the Carpathian Mountains, Odesa, Kherson and Mykolaiv regions.

Wind generators (wind turbines) are devices for converting the kinetic energy of the wind into electrical energy, consisting of a wind turbine, an electric generator and auxiliary equipment. This analysis focuses on small-scale wind turbines. Thus, the focus of the study is private and special purpose wind turbines, which are used to power small objects. According to the design of the wind turbine, two main types of windmills are distinguished - devices with a vertical and horizontal axis.

Devices with a horizontal axis require an additional orientation device and a high mast, but are characterized by a high coefficient of utilization of wind energy and relatively small dynamic loads. Due to their advantages, they have been widely used. A high value of the coefficient of utilization of wind energy is achieved by optimizing the profiles of the turbine blades, it allows to obtain a significant lifting force on the blades, which contributes to an increase in torque. However, such turbines, according to research conducted by Atkins & Partners Overseas, showed that the integration of wind generators into a building is not a good solution for a high cost (it can reach up to 30% of the cost of the entire construction). This is due, first of all, to the costs of additional building design, as well as due to the complex construction of bridges, the complexity of installation, additional loads on the bearing elements of the towers, the high cost of integrating wind generators into buildings, and the like.

An alternative to a horizontal axis wind generator is orthogonal wind generators (with a vertical axis of rotation). The main advantage of such installations is the possibility of placing a generator and a multiplier on the installation foundation, eliminating the angular transmission of torque. This allows you to abandon the powerful, as a rule, multi-threaded angular transmission of torque, to soften the requirements for the installation of equipment (eliminate restrictions on dimensions and weight) and operating conditions (lack of shocks and vibrations). When placing equipment on the foundation, the conditions for its installation and operation are sharply improved, and the transmission of generated electricity is simplified. Slow-moving vertical-axis wind turbines from the point of view of environmental impact have advantages over high-speed horizontal propeller ones: when they are working, all levels of aerodynamic loads and infra-noise are lower, vibration, less television and radio noise, less radius of dispersion of the fragments of the blades in case of their destruction, lower probability collisions of blades with birds. Moreover, according to applicable GOSTs and SNiPs (national standards), such wind turbines can be located on residential, office and industrial buildings, etc.

Vertical windmills are divided into small and large. A small domestic wind turbine with a vertical axis of rotation is mainly used to power small loads. They are usually installed in urban space, on the roofs of buildings. Vertical windmills are located where traditional wind farms with a horizontal axis of rotation cannot be used due to the lack of technical mounting capabilities. Small vertical wind generators can provide

electricity to household appliances such as lighting, sensors, alarm devices. Sometimes they are used to support power during a power outage in a common network, to maintain voltage in uninterruptible power systems (UPS).

Large domestic wind turbines with a vertical axis of rotation are ideal for powering objects in urban areas. They can provide electricity, for example, to power the lighting of common areas, buildings or any other type of residential premises. They are usually installed in places where the main criterion is not the maximum power generation capacity, but an aesthetic appearance for the surrounding infrastructure and ease of installation on the ground. Vertical windmills can be safely installed on the flat roofs of buildings. They are also installed as free-standing installations near the house. Large household wind turbines with a vertical axis of rotation can be used equally for heating and for supplying alternating current to electrical appliances in a building. Together with photovoltaic modules, they can be an excellent source of guaranteed power supply during power outages, for example, for GSM relays or other key elements of a data transmission system. They can also be used for individual residential buildings as an auxiliary power source from the mains. Through a characteristic appearance can be part of the object of advertising. Vertical wind farms with a vertical axis of rotation can be connected to a common power grid, the so-called on-grid system.

So, wind turbines are relevant practice in the modern Ukrainian market. However, it should be borne in mind that the installation of such structures affects the appearance of the building, changing its architecture. This greatly complicates the installation of wind turbines in historic buildings. It is also not effective in terms of energy saving and money for a small amount of energy produced.

Heat pumps

Today, Ukraine is heading towards energy efficiency and preserving the ecology of the environment. In the framework of modern politics, as well as from a savings perspective, in buildings of various types and orientations, one of the most popular and effective technologies is the installation of heat pumps. They, in turn, are compact, economical and environmentally friendly heating systems that allow to receive thermal energy for hot water supply and heating of buildings through the use of heat of a low potential source (heat of soil, ground and artesian waters, lakes, seas, air heat) by

transferring it to a heat carrier with a higher temperature. This technology allows you to receive heat at low ambient temperatures by generating thermal energy both in the environment and due to thermal energy.

In Ukraine, the following heat sources are the most common: ambient air, groundwater, soil, sewage, open water, ventilation air, and industrial waste heat. Based on the types of heat energy sources common in Ukraine, various types of heat pumps are installed in buildings, which differ in their functional features (table 1). The most popular are three types of heat pump: air - air; air - water; water - water.

Table 1

Type of heat pump	Source of thermal energy	Heat carrier that heats up	General features
Air - air	Atmospheric air	Indoor air	1. Relatively high average annual conversion rate; 2. Ability to use existing air conditioning and ventilation systems for heating; 3. Cannot be used for domestic hot water systems (DHWS);
Air-water	Atmospheric air	Water for heating and DHWS	1. More affordable price (compared to other types); 2. Possibility of use for water heating systems for domestic hot water; 3. Air conditioning is provided with a small heat loss;
Water-water	Water (natural or man-made sources)	Water for heating and DHWS	1. Maximum annual average conversion rate; 2. Relatively high implementation costs due to pipelines, pumping station construction, etc.

Soil-water	Soil or ground water	Water for heating and DHWS	1. Constant heat source temperature throughout the year; 2. Significant costs of laying ground probes.

In the Ukrainian market, heat pumps have not yet become widespread, but they have begun to be actively introduced both in the private sector and the public. Most often, the effectiveness of using this heating / cooling method is evaluated when considering individual energy-saving tasks. So, today it is popular to conduct energy audits of individual buildings and their subsequent modernization. An obstacle to the wide operation of heat pumps is their high cost, however, an integrated approach to their operation, including combining heat / cold production and energy use, the optimal choice of sources of low potential heat, etc., significantly compensate this drawback.

Biomass

Solid biofuel is solid biomass that is used as boiler fuel, including firewood, peat, sawdust, wood chips, straw, other agricultural waste, pellets and briquettes made from biomass, charcoal and carbon substances.

According to experts of Ukraine's bioenergy association, Ukraine has already in 2012 made use of a significant part of the energy potential of such types of solid biomass as wood (93%) and sunflower husks (61%), while straw is almost not used as fuel (about 1 %), although it has the greatest energy potential according to the calculations of experts of the Institute of Technical Thermo-physics of NAS of Ukraine.

Based on the analysis of the current regulatory documentation of Ukraine on the reliability of heat supply to consumers of various categories who are connected to centralized heat supply systems, the specialists of the UBO "Institute for Local Development" proposed a concept for the development of bio-heat-energy in Ukraine, which can be applied to the development of autonomous heat supply systems : the use of biomass as fuel in district heating systems can only be successful on the basis of hybrid combined boiler houses, which must operate both on biofuel and natural gas. In this case, the main heat load will be compensated by the operation of the bio-boiler, and the peak load increase during periods of a significant decrease in the outdoor temperature will be compensated by the operation of boilers using traditional fossil

fuels - natural gas. In addition, the presence of boilers using traditional fossil fuels - natural gas in the boiler room is a duplicating factor that provides redundancy of heat-generating capacities in case of emergency, etc.

The state of production and implementation of bio-fuel boilers in Ukraine is characterized by the dominance in the market of boilers designed for burning wood, as well as sunflower husks (industrial boilers at oil plants). The following factors influenced the formation of such a situation: a) the availability of wood as woodworking waste and forestry; b) the properties of wood as a better fuel; c) a wide selection in the market of affordable and reliable boiler equipment for wood burning. Equipment for burning wood (boilers and auxiliary equipment for the preparation, storage, supply of fuel, in particular cod and ash removal) is widely represented in Ukraine, has no technological difficulties and is not technologically unique and can be implemented in regions of Ukraine with significant potential of this type solid biofuels.

In regions of Ukraine where there is a shortage of wood, but enough of such annually renewable waste of crop production, such as straw, it is advisable to introduce boilers that are capable of burning straw. Today in Ukraine boilers for burning granulated or chopped straw are not produced as a standard. There are isolated attempts to use traditional biofuel boilers for the burning of straw, which are intended mainly for burning wood. At the same time, some Ukrainian manufacturers are planning to start production of boilers for the burning of straw pellets and carry out pilot production of the first samples. Using straw as a fuel on high-power boilers, it is recommended to install flue gas filters to ensure that the environmental legislation is met to prevent air pollution. EU practice recommends to use different filters for flue gas cleaning, such as cyclone, hose filter, electrostatic filter, scrubber and flue gas condensation technology for high-capacity boilers.

The use of biomass boilers in public buildings, including buildings of historical significance, is difficult. There are several reasons for this. First, like any type of fuel, biomass in the combustion process produces combustion by-products, such as ash, CO_2 and various gases. Within the city where people live, the chimneys of these boilers are equipped with special filters that minimize the harmful effect. This equipment is expensive and does not pay back its cost during its life, it also requires special care and debugging for proper operation. Secondly, for an uninterrupted heating season, it is

necessary to have a warehouse of raw materials or directly on the territory of the facility, which will create a fire hazard in the territory.

COMMUNITY SCALE

Sustainable transport

During the years of independence of Ukraine, the number of vehicles related to public transport decreased from 12.3 to 6.2 thousand units. According to the Ministry of Infrastructure of Ukraine, about 80% of public transport means do not meet the conditions of transport safety, which are morally and technically obsolete. In addition, non-modern public transport, mainly a bus and car parks, is also ineffective, causes significant damage to the urban environment, worsens the comfort of citizens, causes additional noise, vibration, degrades the quality of air, soil, water, and causes greenhouse gas emissions. Therefore, for Ukraine, the modernization of public transport, especially vehicles, is an urgent need. This also applies to carbon policies, which are ineffective in terms of vehicles in Ukraine.

The Ministry of Infrastructure and the State Enterprise "GosavtotransNIIproject" for the implementation of paragraph 268 of the Action Plan for the implementation of 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, for 2014-2017, approved Decree of the Cabinet of Ministers of Ukraine dated by September 17, 2014 No. 847; The transport strategy of Ukraine for the period until 2020, approved by the Order of the Cabinet of Ministers of Ukraine dated by October 20, 2010 No. 2174 (section "Priorities for the development of road transport") of the Sectoral Programme for Ensuring Traffic Safety in Road Transport for 2013-2015, approved by the Order of the Ministry of Infrastructure from April 04, 2013 No. 210 (with additions made by the Order of the Ministry of Infrastructure from April 8, 2014 No. 171); Concepts of the State Targeted Economic Programme for the Development of Road Transport for the Period until 2015, approved by Decree of the Cabinet of Ministers of Ukraine dated by August 03, 2011 No. 732; The Industry-Specific Programme to Increase Energy Efficiency and Reduce Energy Consumption by Budgetary Institutions through their Rational Use in Transport And Communications for 2010-2014, approved by the Decision of the Board of the Ministry of Transport and Communications from September 17, 2009 No. 18; Decree of the Cabinet of Ministers of Ukraine dated by May 17, 2012 No. 397 “Some Issues of Determining Medium-Term Priority Areas of Innovation at the Industry Level for 2012 - 2016” carried out activities to create a

research and development center for advanced technologies for safe, environmentally friendly and energy-efficient road transport in Ukraine a range within a complex of testing laboratories and related infrastructure and so on. This project is the key to obtaining the technological capabilities of Ukraine to conduct scientific research to increase the requirements for environmental safety of vehicles and the practical implementation in Ukraine of European environmental standards in the field of transport, reduce energy dependence of Ukraine, etc. But this project has not been for lack of funding.

Now in Ukraine, the project "Urban Public Transport in Ukraine" is being implemented. Project content: development, implementation and monitoring of the investment project "Development of Urban Passenger Transport in the Cities of Ukraine" and promotion of the development of a national policy in the field of urban passenger transport, improvement of its regulatory support and implementation of relevant organizational changes at the central and local levels in accordance with the objectives set out in the association agreement between Ukraine and the EU from May 2014.

As part of this project, six subprojects for the development of urban passenger transport were approved for a total of 89 million Euro. The project provides for the renewal of the parks of buses, trolleybuses, trams, subway cars, the construction and reconstruction of tram and trolleybus lines, a funicular, the replacement of traction substations, the introduction of modern fare payment systems and information systems using borrowed funds from the EIN and EBRD.

According to the Ministry of Infrastructure, in particular, in 2018, 167 trolley buses were purchased under the project, including 47 units for Odesa, 40 units – for Kremenchuh, 23 trolleybuses delivered to the Dnieper, 10 - to Kremenchuh, 8 - to Kryvyi Rih. Due to these purchases, taking into account the inventory parks of trolley buses in these cities as of January 1, 2018, Odesa has renewed the park by 28%, Kremenchuh by 70%, Dnipro by 17%, Rivne and Kryvyi Rih by 10% each.

Ukraine, in the framework of the European Investment Bank (EIB) project "City Public Transport of Ukraine", plans to purchase 227 buses, 153 trolley buses, 56 trams and 35 subway cars in 2019, according to the website of the Ministry of Infrastructure.

Given the state of public transport in Ukraine, guided by existing agreements, directives, plans and strategies of the country from the standpoint of energy efficiency

and transport development, the following general recommendations on the modernization of public transport were identified:

1. As public transport, mainly motor transport, is one of the largest environmental pollutants in cities, affects population diseases and requires significant economic costs; modernization of public transport should take into account the environmental features of new vehicles and fuel for them. This is fully consistent with European practice and is gradually being implemented by Ukraine as part of the obligations of association with the EU.
2. The selection and purchase of new vehicles at the expense of municipalities or other sources of financing should be limited and based on the latest environmental technologies, among which there are hybrid, electric, hybrid-electric, biofuel, gas and fuel cell vehicles on the market. The use of conventional vehicles operating exclusively on fossil fuels (gasoline and diesel, fuel oil) should be phased out.
3. Municipalities have in practice to ensure the implementation of the provisions of the National Renewable Energy Action Plan by 2020 for the period according to which the development of transport on such renewable fuels as renewable electricity, biodiesel and bioethanol should be ensured in accordance with the established targets.
4. The introduction of new technologies in municipal transport and the use of renewable fuels instead of traditional fossil fuels requires the gradual bringing to the market level of passenger transportation tariffs as part of the municipal transport reform.
5. Municipalities should develop infrastructure for new modes of transport, stimulate its modernization.
6. The overall existing public transport system should be optimized, which has the potential to significantly improve energy efficiency through the introduction of a number of measures, for example, automation of the management process, optimization of the vehicle park structure in terms of passenger capacity, optimization of vehicle routes, etc.
7. In Ukrainian cities, today it has been already possible to recommend the widespread use of electric buses, as well as hybrid and biofuel vehicles as competitive modern technologies.

PROPOSALS ON THE USE OF ENERGY EFFICIENT TECHNOLOGIES ON EXAMPLES OF HISTORICAL OBJECTS OF THE UKRAINIAN PART OF BLACK SEA BASIN

One of the main problems of historical buildings is their energy inefficiency and high energy losses. To solve these problems in the country, according to the legislation and existing practice, various types of work are carried out. Of course, there are a number of limitations. Firstly, it is a prohibition on changing the architecture of the building, therefore, wet insulation works are being carried out with the reconstruction of all architectural and design elements (murals, stucco mouldings, etc.).

An example of large-scale work on the reconstruction and implementation of energy-efficient technologies in an object of historical significance is the building of the modern Bessarabia hotel in Izmail. This building was built in the late XIX - early XX century. For more than 25 years it was abandoned and was in disrepair. The reconstruction of the building was started in 2016. During the reconstruction of the facility, the foundation was strengthened and the retaining wall was thoroughly repaired, preserving the original appearance of the building, individual elements of its decor. An exception is the tower on the east side.

To heat the building, 2 air-water heat pumps with a capacity of 32 kW each were installed. The heat pump in winter works for heating, and in summer for air conditioning. To ensure a comfortable microclimate, a fan coil was placed in each room, which is a device for controlling the temperature of the air in the room. Chiller is an analogue of multi-zone air conditioning systems. The main difference is that the cooling and / or heating of the air with fan coils is carried out using water or ethylene glycol (antifreeze), while Freon is used in air conditioners. Water is cooled or heated (it all depends on functionality) to a chiller that distributes the heat carrier through the fan coil system. Thus, in heating mode, the efficiency and, consequently, the economy of the heat pump is ensured, because lowering the temperature of the direct line by only 1 °C reduces heating costs by about 2.5%.

But, with all the advantages of a heat pump and a high efficiency index of 3-5 kW of heat (or cold) per 1 kW of electricity, electricity consumption has increased. Therefore, solar panels were installed to cover the building's own needs for electricity. In a neighbouring building on the south side, 102 Risen panels were installed with a

total capacity of 34 kW and a 30-kW converter. This is one example of the introduction of energy-efficient technologies into historical heritage sites.

Project funded by the EUROPEAN UNION

www.greethis.net

LIST OF TECHNOLOGIES, PRODUCERS AND DISTRIBUTORS AVAILABLE AND OPERATING IN UKRAINE

Name of organization	**Contacts** *(website, phone number, addresses, contact person)*	**Description of the organization** *(½ page)*	**Field of activity / Energy efficient measures, lighting, transport, building management system (BMS), energy services, RES** *(One or more options)*	**Good practice examples** *(Links)*
ALTAL GROUP	Address: Ukraine, м. Kyiv, str. Bulvarno-Kudriavska, 31A; Phone number: +38(044)221-40-09; +38(093) 381-53-78; +38 (067) 286-40-17; Address: Ukraine, м. Cherkasy, Hromova str. 138\1; Phone number: +38(097)208-72-02; +38(0472) 71-16-69;	The company was founded in 2004. From the beginning of the establishment of the enterprise, heat pumps with a total capacity of more than 25 mW were produced, and the production capacity of the plant today is 3 mW per month. In addition to production, the company provides full technical support for customers, conducts training seminars.	Energy services, energy efficient activities	www.altal.com.ua

	Address: Ukraine, м. Kharkiv, str. Poliova, 67; Phone number: +38 (057)737-20-65; +38(050)631-57-24; +38 (067)608-55-71; website: www.altal.com.ua			
APRICUS SOLAR	Address: Ukraine, м. Kyiv, Gen. Vatutin ave., 5, 1 floor; Phone number: +38(044) 227-83-03; +38(067) 448-19-09 Address: Ukraine, м. Odesa, Kosmonavtiv str. 32, 108 office; Phone number: +38(048) 704-55-24; +38(067) 484-49-94 Address: Ukraine, Kamianets-Podilskyi, Ohienko str., 22 Phone number: +38(067) 678-15-08; +38(067) 381-66-03. website: www.apricus.com.ua	Apricus products are various types of solar collectors that are designed to produce heat for hot water supply, pool heating, heating system support, by converting solar radiation into thermal energy.	RES	www.apricus.com.ua
VKM WOOD	Address: Ukraine, м. Kyiv, Derevoiobrobna str., 6v; Phone number:	The VKM Wood GROUP holding includes a number of manufacturing enterprises	RES	www.bkmwood.com

	+380(96) 615-69-76, +38(050) 859-16-18; website: www.bkmwood.com	located in western and central Ukraine. The company's products are exported to Italy, Belgium, Croatia, the UK, Poland, Slovakia, Bulgaria, Romania and other countries. The company produces beech wood fuel pellets in its own production, equipped with modern Italian equipment, which allows to maintain guaranteed high-quality products.		
DM-STELLA	Address: Ukraine, Zaporizhzhia, Ivanova str., 81B Phone number: +38(066)555-00-43 website: www.dm-stella.com	The company has been operating for more than 7 years in the market of heating equipment in Ukraine. Working on the principle of pyrolysis fuel combustion, pyrolysis boilers as the main fuel can use not only woodworking waste, firewood and pellets, but also almost any alternative type of fuel.	Energy services	www.dm-stella.com/photos
ECO TECH UKRAINE	Address: Ukraine, Kryvyi Rih, Henerala Radiievskoho str., 19 website: www.eco-tech.com.ua	The company specializes in solar energy and energy-efficient technologies. Quality assurance	Energy efficient activities, RES	www.eco-tech.com.ua/portfolio

		of all components from the manufacturer and after-sales service for the entire warranty period. The company also performs installation, commissioning and training on further operation.		
ENTHEOS	Address: Ukraine, Slavutich, Malozemelna str., 17/18; Phone number: +38(093) 60-20-096; +38(096) 63-35-602; +38(066) 02-68-197; website: www.entheos.com.ua	Manufacturer of geothermal heat pumps, heat accumulators, indirect heating boilers. The company also provides a full range of related works: installation of underfloor heating and walls, radiators, fan coils, phone number ties, installation of solar systems, water supply, sewage, electrical equipment.	Energy efficient activities, energy efficient services, RES	www.entheos.com.ua
EFFI	Address: Ukraine, Vysokyi settl., Voienna str., 1; Phone number: +38 (057) 750-76-63; website: www.effi.com.ua	The profile of the company is the manufacture and installation of climate panels (energy-efficient systems for heating and cooling rooms).	Energy efficient activities	www.effi.com.ua/objects.html

GREEN ENERGY	Адрес: Ukraine, Chernomorsk, Tulchianivska str., 67 Phone number: +38(096) 391-31-93 +38(050) 262-31-97 +38(098) 787-53-53 website: www.green-energy.com.ua	Turnkey solar power plants.	RES	www.green-energy.com.ua/nashi-raboty
ION	Address: Ukraine, м. Kyiv, Khmelnytska str., 10, 8; office; Phone number: +38 (098) 244 88 00, +38 (067) 508 53 70; website: www.energosberezhenie.com	The company "ION" has fifteen years of experience in the development and production of electrode (ion) boilers. The company operates on the latest German equipment and each product is tested on a test bench in many ways. The new alloy of the electrode, which is produced thanks to the latest technology, allows it to be used for up to 30 years.	Energy services	www.energosberezhenie.com
KRAFT	Address: Ukraine, м. Kyiv, Velyka Okruzhna str., 4B, Phone number.: +38 (066) 655-79-49 +38 (068) 022-74-77 e-mail: kotly.kraft@gmail.com website: www.zavod-kraft.com	The company produces solid fuel boilers. The peculiarity of the enterprise is in the international cooperation of German designers and Ukrainian industrialists. All design developments are made	Energy services, RES	www.zavod-kraft.com/project

		by German partners. They also carry out supervision and technical control of product quality. The production equipment of the plant consists only of modern equipment, mainly European brands. There are also machines from American manufacturers.		
LEDLAMP GROUP	Address: Ukraine, Odesa, Preobrazhenska str., 30, 1 office; Phone number: +38(048) 799-89-96; website: www.ledlampgroup.com	Since 2010, LedLampGroup has been producing a wide range of reliable and economical LED lamps (Citizen diodes - Japan).	Lightning	www.ledlampgroup.com/ru/projects.html
MIG ENERGY	Address: Ukraine, Lviv, prof. Buika str., 16; Address: Bucha, B. Khmelnytskoho boul., 2; Phone number: +38(050) 317-31-67; +38 (067) 444-31-67; +38 (097) 303-26-22; website: www.migenergy.com	An official dealer in Ukraine of Alternative Energy LLC (Russia), a manufacturer of vortex induction heaters (VIH).	Energy efficient activities	www.migenergy.com/#obyekty
WARMHAUS	Address: Ukraine, Rivne, Bila str., 16; Phone number: +38(067) 114-51-30, +38(050) 999-25-00; website: www.warmhaus.com.ua	WARMHAUS is a modern Ukrainian production complex that allows producing high-quality solid fuel boilers for solid fuel such as wood, peat	Energy services, RES	www. warmhaus.com.ua

		briquettes and all other types of solid fuel. In the manufacture of products exclusively certified materials are used.		
LLC PKF "Averazh"	Address: Ukraine, м. Kyiv; Phone number: +38(050) 538-03-51; +38(093) 872-37-65; +38(050) 627-15-95; website: www.average.com.ua	Development of a new method for producing thermal energy from electrical energy, as well as devices for its implementation.	Energy services	www.average.com.ua
LLC "ALVI SINERGIIA"	Address: Ukraine, м. Kyiv, Kahovska str., 64; Phone number: +38(044) 223-53-73; +38(098) 214-88-86; +38(050) 331-32-91; +38(044) 353-08-45; website: www.alvisi.kiev.ua	Development and production of thermo-regulating electronics for controlling any climate systems (electric boilers of any type, underfloor heating, air conditioning, saunas).	BMS	www. alvisi.kiev.ua
LLC "ALTGAZ"	Address: Ukraine, м. Kyiv, Zheliabova str., 8/4; Phone number: +38(093) 090-12-80; website: www.altgaz.uaprom.net	This is a multidisciplinary engineering company that specializes in the creation and implementation of its own scientific and technical developments and projects in the field of replacement of natural gas with synthetic combustible gases; the use of non-traditional and alternative fuels; energy saving; use and	Energy efficient activities, RES	www. altgaz.uaprom.net

		processing of collateral and secondary resources. The main activities of the company are the design and manufacture of gas generators (gasifiers) of solid fuel; integrated design of various machines and devices; production of biofuel briquettes (Pini-Kay, RUF); design developments for the disposal of sludge and waste.		
ALTEP-CENTR	Address: Ukraine, Chernihiv, Malinovskoho str., 34 Phone number.: 0 800 30 90 90 E-mail: service@altep.ua website: www.altep.ua	The company was founded in 2005 and specializes in the manufacture of boilers with an environmental certificate and a certificate of emission and energy tests carried out by authorized organizations.	Energy services	www. altep.ua
ATMOSFERA	Address: Ukraine, м. Kyiv, Symferopilska str., 13-A; Phone number: +38(044) 545-71-04; +38(093) 426-37-10; +38(067) 445-45-98; +38(050)440-01-74;	Distributor of equipment and solutions in the field of renewable energy with heat and electricity supplies of hot water supply (Ukraine, Belarus, Moldova, Poland and China).	RES	www.atmosfera.ua/ru/portfolio/katalog-obektov/

	website: www.atmosfera.ua			
NPE “BELITSKII R.M.”	Address: Ukraine, Izmail, Kutuzova str., 11 Phone number: +38(048) 4159777	Installation of individual heat stations, solar power plants, heat pumps.	Energy efficient activities, RES	
EKOENERGIIA	Address: Ukraine, м. Kyiv, Nikolia Vasylenka str., 7, 709/3 office; Phone number: +38(068) 688-77-22; website: www.ecoenergy.com.ua	The main activities of the company were energy-saving technologies in industry and technologies for processing solid industrial waste in metallurgy, chemical and coal processing industries. Recently, special attention has been paid to developments in the field of renewable energy and optimization of local energy consumption systems.	Energy services, RES, energy efficient activities	www. ecoenergy.com.ua
LLC ”EKOTECHNIK UKRAINE”	Address: Ukraine, Kyiv, Horlivska str., 226/228; Phone number: +38(044) 393-92-15 +38(067) 214-20-15; website: ekotechnik.com.ua	Representative of the Czech company EKOTECHNIK - a leader in the design and investment in solar energy.	RES	www.ekotechnik.com.ua/
LLC “EKOLAIT UKRAINE”	Address: Ukraine, Vyshneve, Vytianska str., 1-a, 6 office; Phone number: +38(067) 484-48-68, +38(044) 406-37-30;	Supplier of LED luminaires and lamps of the ECOLIGHT trademark.	Lightning	www.ecolight-ua.com.ua

	website: www.ecolight-ua.com.ua			
LLC “EKOTERMOINZHYNIRYNG”	Address: Ukraine, Kharkiv, Artema str., 15, 5 floor; Phone number: +38(057) 754-59-50; website: ecothermo.com.ua	The company is a leader in the Ukrainian market for the implementation of energy-efficient projects and solutions in heating, ventilation, air conditioning, hot water supply and heat recovery systems; solves the problem of reducing energy consumption and the use of secondary and renewable energy sources.	Energy efficient activities, Energy services	www.ecothermo.com.ua/our-objects.html
LLC “ELIOS STRATEHIA”	Address: Ukraine, Kyiv, Rybalska str., 22; Phone number: +38(067) 571-48-00; website: www.heliosstrategia.com	Distributor of solar panels, inverters, etc. (France).	RES	www.heliosstrategia.com
LLC “ENERGOTEHNOLOHII – IZMAIL”	Address: Ukraine, Broska v., Tyha str., 15, block B Phone number: +38(048) 4140839	Sale and installation of solar panels, supports for LED lighting.	RES	
LLC “IHMATEX”	Address: Ukraine, Kyiv, Pryluzhna str., 4/15, 502 office; Phone number: +38 (044) 451-87-52 website: www.inmatech.com.ua	Representative of the leading German companies Weinig and Hargassner world manufacturers of woodworking machinery and more.	Energy efficient activities, RES	www.inmatech.com.ua

NPE "ZHELIAPOV D.H."	Address: Ukraine, Izmail, Tulchianivska str., 53 Phone number: +38 (067) 557-49-98	Sale and installation of heat pumps, solar collectors.	RES	
LLC "KS SOLAR"	Address: Ukraine, Kropyvnytskyi, Yanovskoho str., 100 Phone number: +38 (099) 150-05-03 +38 (099) 150-08-08 +38 (099) 150-05-05 website: https://kssolar.com.ua	The company specializes in the acquisition and construction of solar power plants of arbitrary complexity and power by turnkey.	RES	www.kssolar.com.ua/#portfoliolink
LLC "NAVIHATOR UA"	Address: Ukraine, Kyiv, Derevopererobnyi lane, 5; Phone number: +38(097)440-61-31; website: www.werden.prom.ua	Manufacturer of heat storage tanks WERDEN for ELEKTROMET. The production capacities of the enterprise make it possible to manufacture containers from 0.1 m^3 to 10 m^3 inclusive. In addition to the basic version, products can include tanks with heat exchangers for connecting solar systems, HWS (stainless steel heat exchanger), as well as an output for connecting an electric heater for additional heating of the coolant.	RES	www.werden.prom.ua

LLC Liuksen	Address: Ukraine, м. Kyiv str. І. Дьяченко,5 Phone number: +38(067) 443-41-85 +38(050) 512-44-79 +38(044) 222-59-89 +38(073) 439-58-02 website: www.luxen.in.ua	Supplier of heat pumps and solar water heaters, recuperators.	RES	www.luxen.in.ua
LLC “ODESA CLIMAT”	Address: Ukraine, Odesa, Kompozytora str., Nishchynskoho str., 22 Phone number: + 38 (048) 770-22-02 + 38 (067) 487-47-90 + 38 (048) 771-77-50 website: www.odessaklimat.com.ua	Supplier of heat pumps, solar collectors, ventilation, photovoltaic modules, boilers, air heat curtains, etc.	Energy efficient activities, RES	www.odessaklimat.com.ua
LLC “PROMYSLOVI SYSTEMY”	Address: Ukraine, Kyiv, Kyryllivska str., 40; Phone number: +38(044) 238-66-00; website: www.ledps.com.ua	Manufacture and sale of LED equipment.	Lightning	www.ledps.com.ua
LLC “PRANA PLATINUM”	Address: Ukraine, Lviv, Kulparkovska str., 93a; Phone number: +38(032) 232-53-39; website: prana.org.ua	Producer of modern technologies in the field of energy saving: ventilation systems, PRANA recuperators, thermal insulation systems ECOTEMP.	Energy efficient activities	www.prana.org.ua
LLC “PROLOH SEMIKOR”	Address: Ukraine, м. Kyiv, Hlushkova ave., 42V; Phone number: +38(044) 502-63-79, +38(044) 526-13-64;	One of the leading manufacturers of materials, components and equipment for	RES	www.semicor.com.ua

	website: semicor.com.ua	solar energy and microelectronics in Ukraine.		
LLC “RADII”	Address: Ukraine, Kirovohrad, Heroiv Stalinhradu str., 29; Phone number: +38(0522) 37-33-28, +38(0522) 37-31-16; website: www.radiy.com	Manufacturer of energy-saving LED lamps for the industry.	Lightning	www.radiy.com
LLC “ ROZUMNYI DIM”	Address: Ukraine, Kyiv, Kurenevskyi lane, 17; Phone number: +38 (044) 499 92 76, +38 (067) 489 59 43; website: rdim.ua	One of the leaders in the market of heating electrical systems. Works since 2006. Main services - supply, design and installation of systems: floor heating, anti-freezing, snowmelt, industrial heating, water leakage systems, lightning protection and grounding systems, temperature regulators, etc.	BMS, energy systems	www.rdim.ua/ua/our-objects/special-proj.htm
LLC “RENTEHNO”	Address: Ukraine, Kyiv, Oleksandra Pirohovskoho str., 19, block 4; Phone number: +38(044) 332-81-90; website: rentechno.ua	The company is focused on developing and investing in the Ukrainian energy market for engineering solutions using renewable energy sources.	RES	www.rentechno.ua/portfolio.html
LLC “SANTEHKOMPLEKS”	Address: Ukraine, Kyiv, Kurenevska str., 16a; Phone number: +38 (044) 499-29-90; +38 (044) 459-00-41;	Sales, installation and service of OCTOPUS heat pumps (Sweden).	RES	

	+38(044) 390-70-17; +38(044)499-29-57; website: santehkomplekt.ua			
LLC “SVITLODAR”	Address: Ukraine, Brovary, Kyivska str., 292; Phone number: +38(045) 946-29-72, +38(045) 946-29-21; website: svitlodar.kiev.ua	Ukrainian enterprise for realization of own engineering decisions in the field of LED lighting.	Lightning	www.svitlodar.kiev.ua
LLC “ SOLID TEPLOENERHO”	Address: Ukraine, Kyiv, Dmytrivska str., 66A, 54 office; Phone number: +38(044) 486-44-46, +38(097) 329-95-10; website: solid-teploenergo.com.ua	Group of companies for production, sale of fuel pellets and implementation of projects in the field of heat generation.	Energy efficient activities, RES	
PE “SPEKTR-PRODUKT”	Address: Ukraine, Obuhiv, Myru str., 17V, 3 office; Address: м. Kyiv, Dilova str., 6, 56 office; Phone number: +38(044) 360-00-88; website: www.sproduct.com.ua	The company is actively working on the implementation of programs for the construction of TPPs and CPs, working on different types of alternative fuels, including biomass, with the production of electricity at the "Green" tariff.	Energy efficient activities, RES	www.sproduct.com.ua/proekti/
LLC “STALA ENERHIA”	Address: Ukraine, Zymna Voda v., Doroshenka str., 3; Phone number: +38 (096) 777-56-77; +38 (032) 290-25-46;	It is the official and the only representative in Ukraine of American heat pumps Water Furnace. The company designs and installs heating, air	RES	

	website: stala-energia.com.ua	conditioning and hot water systems based on heat pumps.		
LLC “STAR ENERZHI”	Address: Ukraine, Odesa, Chervonoslobodska str., 1/6; Phone number: +38(048) 795-54-48; website: www.star-energy.com.ua	The first national manufacturer of solar vacuum collectors.	RES	www.star-energy.com.ua/objects.html
LLC “TORGIVELNA KOMPANIA “OPTIM”	Address: Ukraine, м. Kyiv, Pshenychna str., 9 Phone number: 0-800-50-70-65 website: www.optim.ua	The company offers equipment in combination with a full range of services: from the development of project documentation, the selection of equipment and its installation, to commissioning, as well as warranty and post warranty support.	Energy efficient activities, Energy services, RES	www. optim.ua/objects
LLC “UKRTEPLOENERHOMONTAZH”	Address: Ukraine, Kyiv, Verbytskoho str., 1-R; Phone number: +38(044) 500-68-67, +38(097) 012-11-11, +38(050) 380-11-60; website: www.utem.org.ua	Importer and seller of equipment for energy supply systems based on renewable energy sources, such as solar panels (Japan and Germany), mains and autonomous inverters (Netherlands), batteries and solar collectors (Netherlands).	RES, Energy services	www.utem.org.ua/gallery/alternative

LLC "UKRTEPLOK ERAMIK"	Address: Ukraine, Kharkiv, Poltavskyi Shliah str. 188; Phone number: +38(057) 758-12-13, +38(067) 850-82-23, +38(066) 899-90-59, +38(093) 027-33-49; website: www.ukrteploceramic.com	Development and production of an original thermal insulation system: an energy-saving coating with high thermal and waterproofing properties, and is not exposed to ultraviolet radiation.	Energy efficient activities	
FABRYKA TEPLA	Address: Ukraine, Kyiv, Kyryllivska str.; 69V; Phone number: +38 (067) 550-27-22; +38 (067) 507-69-47; website: www.fabrika-tepla.com.ua	The company began its work in 2015 and specializes in heating systems and geothermal heat pumps; the formation of solar power plants (grid, hydride, autonomous) for commercial facilities and private farms. It provides a number of services: heat engineering calculation, energy audit, thermal imaging, project development and turnkey execution.	RES	www.fabrika-tepla.com.ua
PE "KHIMTEKS"	Address: Ukraine, Kyiv, V. Brozhka (Kirovohradska) str., 64.; Phone number: +38(067) 111-80-36, +38(044) 223-81-36, +38(094) 823-81-36; website: www.himteks.net	The Khimteks enterprise was founded in 1995, and is currently one of the largest suppliers of thermal products on the Ukrainian market.	RES, BMS, Energy services.	www.himteks.net/nashi-raboty

LLC “TSETUS”	Address: Ukraine, Cherkasy, Hromova str., 138/1; Phone number: +38(097) 208-72-02; +38(0472) 71-16-69; Address: Ukraine, Kharkiv, Poliova, 67; Phone number: +38(057) 737-20-65; +38(050) 631-57-24; +38(067) 608-55-71; website: www.cetus.org.ua	A manufacturer of renewable energy technologies based on wind-solar systems, solar collectors, heat pumps.	RES, Energy services	www.cetus.org.ua/foto-sistemy-generacii.html

CONCLUSIONS

Ukraine today is actively introducing and disseminating various practices of energy efficiency and the use of alternative energy sources. It should be noted that from the point of view of alternative sources (primarily solar and wind energy), the south of Ukraine (the Program area) is the most suitable in terms of geo-climatic parameters. With regard to energy efficiency, the country is actively working to introduce new European and world practices in the field of energy both at the legislative and practical levels. Various works are underway to isolate the buildings, install new equipment for ventilation, air conditioning, as well as updating water supply systems, etc.

From the perspective of modernization of buildings of historical significance, there are a number of restrictions that do not allow the use of all available resources. However, certain types of energy efficiency works are possible that will not change the appearance of the building, for example, using wet plaster to insulate the facade, warming the roof, installing modern wooden windows and preserving their original appearance, using a combination of natural and mechanical lighting, installing LED lamps etc.

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