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This monograph presents the approaches and tools for green building, research results of assessment the potential of Europe for preservation and renovation of natural recourses to create the sustainable environment for life and industrial activity. New architectural, structural and technological systems for construction low-rise buildings with using diffrerent materials have been considered and proposed. In the book, the technologies of energy efficient building design and construction are described.

It can be used as Urban Agenda for Regions` Sustainable Development. For researchers, university students, municipal administration, managers of business structures.

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URBAN AGENDA FOR SUSTAINABLE DEVELOPMENT

1.1. CREATION OF HIGH-TECH AGRARIAN CLUSTERS AND SOCIO-ECO-COMPLEXES IS A STRATEGY FOR THE DEVELOPMENT OF UKRAINE

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On September 2015 the United Nations gave final approval to the 17 Sustainable Development Goals (SDGs) for the year 2030 [1], which replaced the Millennium Development Goals (MDGs) (2000-2015) [2]. The overarching purpose of the SDGs is to end poverty, protect the planet, and ensure prosperity for all.

The World Economic Forum [3] has singled out 10 key global challenges that require cooperation from the governments, private sector, civil society, science and education sector. The most important ones are the following: agriculture and food security, economic growth and social inclusion, preventing illness and preserving the health of populations.

A major role in addressing these problems are the agricultural and construction sectors of the economy that provide basic human needs (Maslow) [4].

This is especially true for developing countries, which include Ukraine. However at present, the agricultural sector not only provides food, but is one of the largest supplier of waste.

Buildings and communal services is one of the most energy-intensive sectors of the world economy. Homes and buildings in industrialized countries represent to 40% of total energy consumption [5], of solid waste, greenhouse emissions, of the world's current output of raw materials, 12% of drinking water consumption. By 2025 buildings will use more energy than any other category of “consumers” (today, in the United States they represent 72% of energy use).

A new sustainable development paradigm is based on the provisions of the physical, circular, «green» economy. The study of physical economy focused on the

analysis of the problem of combining economic efficiency and equity in income distribution [6]. The circular economy is an economy that is producing no waste and pollution [7]. This is contrast to a linear economy which is a «take, make, dispose» model of production. A concept of green economy is usually includes those sectors of the economy, which are oriented on production of renewable forms of natural capital [8].

The promising direction of Ukraine's development is modernization of the agrarian sector, development of rural territories through the use of accumulated millennial traditions and integration of modern technologies for the creation on the basis of existing villages of high-tech socioecomplexes, designed to solve important social problems and preserve the natural potential and cultural traditions of the Ukrainian people.

Development of building ecotechnologies in combination with modern bio-agrotechnologies can provide Ukrainians with affordable quality housing worthy of safe and useful work with green technologies on the ground, in tourism and science; to create a new youth-attractive ideology for restoring cultural heritage, cultivating a healthy lifestyle and contemporary thinking in line with the global trend of sustainable development.

According to the Constitution of Ukraine "Land is the main national wealth ..." (Article 14). This is objectively confirmed by the fact that today the agrarian sector is one of the most important sectors of the Ukrainian economy. In our country, which occupies 0.4% of the Earth's land, about 27% of the world's black soil (“chernozem”) reserves is concentrated. According to its physical, structural, mineralogical, chemical, agrochemical properties, Ukrainian chernozem is considered to be the best in the world. No wonder the Ukrainian nation is considered one of the oldest grain-producing nations. The climatic conditions also contribute to this direction of economic development: relatively mild winters, warm summers, sufficient sunshine in the year, moderate humidity, and sufficient rainfall make practically ideal conditions for the cultivation of all major agricultural crops. Ukraine has long been the breadbasket of Europe and according to experts is able to feed about 500 million

inhabitants of the Earth.

The urgent need to preserve the environment and ensure the population of the Earth with high-quality food products leads to the search and application of new, alternative, intensive agricultural models based on the concept of obtaining high-quality crops without compromising the environment through the study and taking into account the processes occurring in nature.

To date, alternative methods of agricultural production include: organic agriculture; bio-intensive mini-farming; biodynamic agriculture; ecological agriculture; agrotechnics using microbiological preparations and preparations based on spores of fungi (EM technologies); balanced agriculture with low resource intensity; precision agriculture; regenerative agriculture; agrotechnics based on worm compost, humic preparations and siderates; agrotechnics using energy information components; other technologies that exclude the use of mineral fertilizers.

The key to the prosperity of mankind is to engage in the great cycle of Nature and wisely support it. Today, the unity of matter, energy, and information for researchers in living systems is becoming increasingly apparent. Awareness of this is the need to understand agriculture as a global space process - the transformation of energy and information flows of the Cosmos, the Sun, and the Earth through plant seeds, soil, environment in the process of photosynthesis into absolute value added. Understanding and conscious application of new economic relations based on natural law equivalent to the exchange, consumer co-operation of free owners-co-owners-producers and fair economic methods creates a new economy - the economy of investing and implementing new ideas and projects, the economy of intensive technological development, welfare and development man, economy of the 3rd millennium.

Ukraine on the level of food security far exceeds the results of all other countries in the world. Ukraine can adequately answer the three main challenges of our century - food production, water supplies, energy sources.

Extremely important for the agrarian sector of the economy is not only the growth of production volumes, but also the development of rural social infrastructure:

housing, roads, kindergartens, schools, medical institutions, shops, processing enterprises, cultural establishments. In a market economy, large agroholdings are not interested in this; therefore, a state program for the development of rural areas is needed.

The village is the center of preservation of national traditions, respect for the family and the connection of generations, which has a decisive influence on the formation of the Ukrainian mentality. Ukraine, first of all, is an agrarian state, its formation was under the influence of the processes that took place in villages. At the present stage, an independent Ukrainian state faces a difficult task of reviving the village.

Thus, modernization of the agrarian sector of the economy on the basis of the development of agrarian and construction technologies is extremely relevant for Ukraine. Modernization of the agrarian sector of Ukraine's economy is possible on the basis of the development of high-tech agrarian socioecomplexes

The main direction of the nearest time it is necessary to consider the sustainable development of rural areas through reconstruction of both existing and creation of new types of individual farms and communities. The organizational form of the creation of new formations can be agrarian and building clusters (ABCs). Cluster is completely self-sufficient that can power and feed itself with closed internal cycle of material and energy flows and the external supply of products and surplus energy to other consumers.

The concept of a non-governmental national project for rational development of the Ukrainian people on the basis of natural agriculture includes, first of all, the construction of high-tech agrarian socio-eco-complexes.

It is developed on the basis of an analysis of trends in the processes of globalization and the role of Ukraine in the global division of labor, on the basis of the principles of balanced (sustainable development), the characteristics of the modern postindustrial information society ("knowledge society"), the formation of a "national idea", the experience of existence on the territory of Ukraine, the farming Trypillya culture, the experience of the existence of the Cossack "winterers" and

farms, the modern technologies of natural agriculture, the study of world experience of existence ecological settlements, innovative energy-efficient, building and information technologies.

The term "high-tech agrarian socioecomplex" means the social environment in which people live, work, rest and in which production (on the basis of the use of high agrarian technologies), scientific (aimed at creating innovative projects), the educational activity of a person is safely and harmoniously integrated in the natural environment in a way that supports the free, healthy, comprehensive human development and is responsible for future generations.

The basic principles of the establishment and functioning of agrarian socioecomplexes are: environmentally friendly, high-tech, business and social activity of residents, comprehensive human development.

The principle of environmental friendliness means the use of technology and life of people in the socioecomplex, preserves and does not destroy the natural habitats of flora and fauna, fit into the natural environment, have a beneficial effect on the environment, materials of structures of buildings and structures are environmentally friendly and do not harm human health.

The high technology of socioecomplex is due to the need to ensure resource conservation, energy efficiency, competitive advantages to ensure economic efficiency. This creates an effective symbiosis of classical and advanced technologies in agriculture, construction, communal economy, energy, computer science, communication, education, and others.

With regard to agrarian technology, it's useful to get acquainted with the report of Policy Horizons Canada " MetaScan 3: Emerging Technologies", which deals with technologies that will radically change agriculture.

Automatic sensing systems allow real-time monitoring of land characteristics, afforestation and water masses and will become a significant addition to automated farms. Thanks to telemechanical equipment, mechanical devices, such as tractors, will be able to warn the driver of a breakdown before it happens. Animals will wear devices (collars, clamps, chips, etc.) to track and transmit information about their

biometric indicators in real-time. The crop sensors will be able to determine the required amount of organic fertilizers and crop condition.

In the future, scientists will create completely new modifications of agricultural animals and plants for better satisfaction of human needs. Unlike genetically modified, genetically grown foods will be created from scratch. In vitro meat can be translated as artificial meat, meat in a tube or vitro, i.e meat that has never been part of an animal.

Monitoring the use of resources using automation technology will save material resources - seeds, minerals, fertilizers and herbicides. Equipment will be able to pre-calculate the area on which the above resources will be used, and "understand" what productivity in one or another part of the field.

Agricultural robots (Agbot - Agricultural Robots) can be used to improve labor efficiency, which can be used for various purposes: for the automation of agricultural processes such as harvesting or fruit harvesting, plowing, soil care, weeding, planting, irrigation and so on.

Precision farming is based on observing and responding to differences (heterogeneity) within a single plot of land. The latest technologies, such as satellite imagery and special sensors, are used to track these heterogeneities. Exact farming allows you to determine the problem areas of the field and to make fertilizers not throughout the area of the field, but only where it is needed. Precision farming helps farmers increase yields and save resources. Precision agriculture, as well as geolocation weather data and sensors, is a step towards the creation of automated technologies for making robust solutions in agriculture.

Robotic farms are a combination of dozens or hundreds of agricultural robots, as well as thousands of microscopic sensors that can monitor, predict, grow and harvest with minimal human participation.

Closed ecological systems that do not depend on external changes, will be able to process waste in oxygen, food and water. This will help maintain existence within the system.

Synthetic biology means biological programming based on standardized

templates. The purpose of the technology is to create (or restore) artificial biological systems that can process information, manage properties, create materials and structures, produce energy, provide nutrition, and maintain and improve human health and the state of the environment.

Vertical agriculture, vertical farms, as a type of urban agriculture, can grow plants or living organisms in special skyscrapers, using greenhouse technology and energy efficient lighting. Benefits: the ability to produce products throughout the year, independence from weather conditions, and reduced transport costs.

All these technologies, no matter how futuristic they look, are being developed today and will be implemented in the next ten years.

The next basic principles of the creation and functioning of agrarian socioecomplexes are the business and social activity of the inhabitants, the comprehensive development of man, which means creating conditions for stimulating entrepreneurship, efficient use of resources and active life positions, human development, both professionally and personally, on the basis of advanced educational technologies.

The scale of the socioecomplex and the optimal number of inhabitants should provide conditions under which all residents know each other, and at the same time everyone is aware that it can affect the development of the socioecomplex. According to available data, the upper limit of this group is approximately 500, and the optimal number is 300 people. Given the average composition of the family 3 - 4 people the optimal number of individual residential buildings in the socioecomplex may be 70-100 units.

Safe integration into the natural environment of the socioecomplex is based on the study and effective use of existing natural mechanisms. This implies that a person is a part of nature and its partner. The next feature is the multiple use of material resources instead of one-time use, which is typical of the consumption society.

In the socioecomplex priority is given to the following areas:

a) energy-saving technologies;

b) the use of renewable energy sources (biomass, hydrogen, biogas, solar

energy, wind, etc.);

c) composting of organic wastes, which thus return the land and subsequently are effectively used;

d) ensuring the processing of inorganic wastes, which may be carried out by the socioecomplex to reduce the harmful effects on the environment;

e) use of materials, structures, devices and engineering equipment that has minimal environmental actions at their disposal at the end of the life cycle.

As already noted, the method of organic (natural) agriculture (permaculture) is at the basis of the creation of the biosystem and the management of agriculture in the socioecomplex. The method of natural agriculture is unique in that it is based on the creation of ecosystems in the nature of natural communities. In applying to the socioecomplex this means the creation of a stable, partially closed ecosystem, the biopotential of which will be large enough to ensure, without damage to the system itself, to fully provide the population with food and other organic materials.

When designing socioecomplex, the concept of building ecostructures is used taking into account the stages of their full life cycle (extraction of materials, construction, exploitation, utilization) and the following requirements:

a) conducting mandatory geoecomonitoring for the selection of a favorable territory of construction, where there are no harmful external actions (noise pollution, air pollution, soil pollution, groundwater, geopathogenic zones, etc.);

b) comfort of the dwelling, fulfillment of sanitary norms at affordable prices, both during construction and in subsequent exploitation;

c) reduction of consumption of energy and other resources due to the use of resource and energy-efficient technologies;

d) minimizing the harmful effects on humans and the environment through the use of environmentally friendly renewable organic materials (wood, cane, hemp, straw), local materials (clay, ground concrete) and low-yielding technologies;

e) audit (upon commissioning) and monitoring (during operation) of the technical condition, indicators of comfort, energy efficiency, environmental parameters of the building.

Taking into account that the future of humanity's development in the knowledge society, the socioecomplex together with agrotechnologies develops, first of all, the information economy, in which most of the gross domestic product is provided by the activity of producing, processing, storing and disseminating information and knowledge. Here we come to the forefront of work with the information product: programming, book creation, consulting and training, development and implementation of know-how, etc.

Thanks to the intensive information exchange and new methods of scientific research, model ideas, the socioecomplex themselves will be factors of advancement of science and innovative technologies.

Today, we have developed a number of pilot projects in Ukraine for the rehabilitation of existing and development of new self-sufficient agrarian and building clusters. The aim of these projects is the creation demo facilities for high tech events as a showcase for further distribution, measurement and monitoring of environmental parameters, the built environment and human capacity.

Agrarian and building clusters (ABCs) have not only environmental and financial value, but also social value, by solving the housing problem, reducing of the rural depopulation, contributing the return of city residents into the rural area and creation of jobs, creating a framework of the self-sufficient families and communities, reconnecting and harmonizing people with nature, self-fulfillment and achieving happiness.

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1.2. UKRAINIAN CONSTRUCTION STANDARDS TO APPLY IN SUSTAINABLE BUILDING DESIGN

Babenko Maryna, Savytskyi Mykola, Kotov Mykola

Today the building is considered as a complex system of elements, which is present by **input value** (materials, sources, energy, etc.) asses by **output value** (emission, waste, etc.) and by **outcome one** (quality of people use the building). Each element is taken into account according to the general principles of sustainable development. Every year there are a lot of new normative and standards appear to ensure the implementation of energy efficiency and ecology in daily practice of building engineers. There are numerous of standards which are being under development currently in EU in the international legitimate level and in the world in the commercial level.

For Ukraine adaptation such new standards is the strategic issue in several meaning: to provide energy independence in the building sector (development of energy autonomic, energy effective green buildings) and to approach to the well developed international community of sustainable (responsible) engineering, create attractive investment base.

Complex studying of existing national Ukrainian normative in the field of ensuring energy efficiency in constructions and its comparative analysis will simplify the understanding of gaps between national legitimate and acting in EU one; develop the working basic instrument for engineers to design in sustainable way by existing norms.

The literature study and comparative analyze were used as the base of the present research. All the studied standards in the field of green building were divided in two general groups: normative and voluntary, each of which listed other sub-groups (Fig. 1).

There were defined current Ukrainian standards in the field of energy efficiency and environmental housing design for compliance with European analogues and standards of sustainable. Those European standards that today have no analogues in Ukrainian norms, but which are important in the development of

sustainable buildings projects are highlighted as N/A.

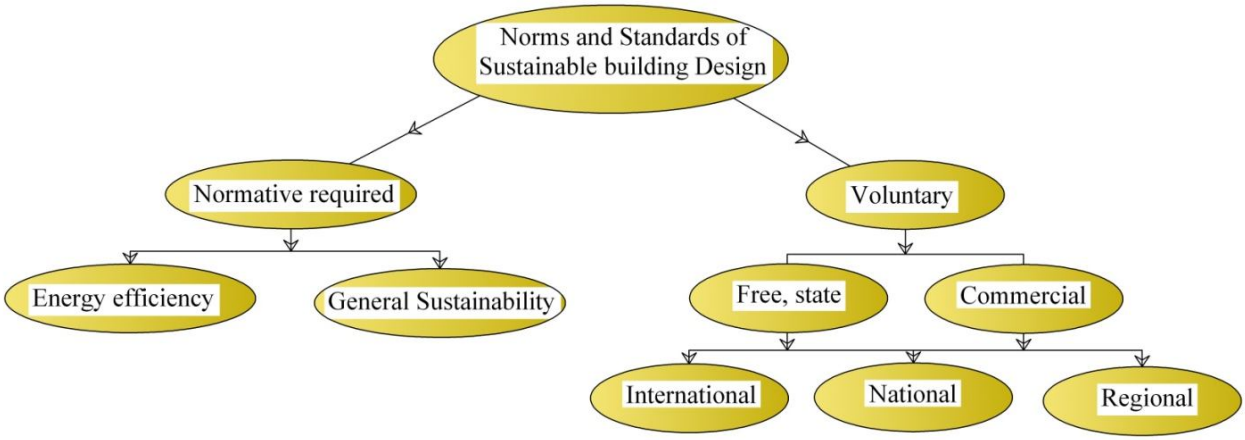

Fig. 1 Hierarchy for effective acting norms analysis

The voluntary standards applying around the world in construction sector were studied. The criteria which are in priority in the context of actual situation in the construction sector of Ukraine were determinated and on their base the assessment of environmental parameters of building objects.

Normative required construction standards in the field of energy efficiency and sustainability requirements Ukraine and EU.

Adopted in 2005, Directive 2005/32 / EC sets requirements for the environmental and energy components of products. In accordance with this Directive, manufacturers of products are required to take measures to reduce energy consumption and other negative environmental impacts throughout the life cycle of products. This approach was called "eco-design"- from resources to utilization within the chain: natural resources - production - transportation - exploitation - utilization. In order to expand the scope of the aforementioned directive in 2009, Directive 2009/125 / EC on eco-design was enacted, which included the inclusion of not only energy-intensive, but also some products that affect energy consumption (eg plumbing). The following stages of the product life cycle are formed: the definition of raw materials and materials, design, production, packaging, transportation, implementation, installation, use, maintenance, utilization. For each stage of the product life cycle, environmental aspects are assessed according to the following

parameters set by the Directive: expected costs of raw materials, materials, energy and other resources; Expected emissions into the atmosphere, water or soil; pollution due to physical factors of the environment; the ability to recycle, recycle and dispose of materials and / or energy.

The EU has the most significant experience in the application of methods for technical regulation of energy efficiency [8]. The main types of regulatory legal documents used in the EU are as follows:

- regulations (fully binding and applicable in all Member States);

- directives (binding on Member States in terms of results to be achieved and to be reflected in the national legal framework);

- decisions (required only for the entities to which they are addressed);

- recommendations and conclusions (not binding and are declarative documents);- standards (applied on a voluntary basis, but various measures are taken in the EU to stimulate their application).

To date, the EU has a large number of regulations and directives aimed at implementing energy efficiency. The main instrument for regulating energy efficiency issues in the EU is regulations, directives and standards. In the practice of technical regulation of energy efficiency in the EU there are two main methods - marking energy efficiency and setting requirements for eco-design products (environmentally-oriented design).

In 2010, Ukraine joined the Energy Community Treaty, which required the enactment of the laws, regulations, and administrative provisions necessary to comply with the requirements of the Directive 2009/28 / EC of the European Parliament and of the Council of 23 April 2009 on the promotion of to the use of energy from renewable sources.

In accordance with the decisions of the Energy Community, the following Directives of the European Parliament and the Council on Energy Efficiency are required: Directive 2006/32 / EC on energy end-use efficiency of energy and energy services; Directive 2010/31 / EC on energy efficiency in buildings; Directive 2010/30/ EC on labeling and standard product information, energy consumption and

other resources by energy products. In view of the need to ensure the effective implementation of international energy efficiency criteria and the detection of gaps in the national regulatory and technical base, it is necessary to carry out an analysis of existing EU regulatory documents and compare them with existing ones in Ukraine or to establish the absence of such.

Absolutely correct comparison is difficult for a number of reasons, namely:

1. There is no possibility to compare energy efficiency classes, because the main condition though is the same for Ukrainian and European energy efficiency standards, but they are calculated in different ways. Since the results are given in different units of measurement, and take into account different factors [1].

2. European regulatory framework in the field of energy efficiency, with initially higher requirements for the construction site, began to form much earlier than in the Ukrainian SSR and independent Ukraine. In addition, it is comprehensive, taking into account not only the amount of heat loss and the costs associated with providing a comfortable temperature, but also takes into account the amount of carbon dioxide emissions, not only when operating a ready building, but also during extraction, production and transportation of materials, i.e. throughout the life cycle, affecting the principles of the non-circular economy, considering buildings as a complex structure with subsequent processing and full disposal at the end of its life of all without exception Ia structural elements.

3. Ukrainian regulatory documents in the field of energy efficiency have been published and supplemented, with higher requirements for heat loss since the beginning of the 2000th year. However, their number is insufficient, some are superficial, and they do not cover a significant range of parameters that must be taken into account and normalized for the possibility of designing reliable, durable, energy-efficient and eco-friendly housing. As can be seen from Table 1.1, Ukrainian norms can be compared with European norms, at best only partially, and for frequent Ukrainian analogs simply are absent.

Table 1.

Comparative analysis of energy efficiency standards in the EU and Ukraine

Title	Content	Nearest Ukrainian counterpart
Energy performance of building		
Directive EPBD (On Energy Performance of Buildings) - the basis of all EU energy efficiency standards.	The purpose of this directive is to achieve a comprehensive energy efficiency improvement for all EU buildings	Law of Ukraine "On Energy Efficiency of Buildings"
EN 15217 Energy performance of buildings - Methods for expressing energy performance and for energy certification of buildings	This standard is devoted to methods for determining the energy performance of buildings, as well as drawing up a certificate of energy efficiency.	DBN V.2.6-31:2016 (partially)
EN 15603 Energy performance of buildings. Overall energy use and definition of energy ratings	The purpose of the standard is: a) compare the results of other standards that calculate the use of energy for one or another service within the building; b) take into account the energy produced in the building, a certain part of which may be transferred for use elsewhere; c) provide a summary of the energy use of the building in tabular form; d) provide energy assessment based on primary energy, carbon dioxide emissions or other parameters specified by the national energy policy; (e) Establish general principles for calculating primary energy factors and carbon emission factors. This standard defines energy services that need to be taken into account for rating energy performance for projected and existing buildings. f) method for calculating the standard calculated energy rating (passport), standard energy usage, which does not depend on the behavior of residents, actual weather and other actual (surrounding or internal) conditions; g) method for estimating the energy rating (passport) on the basis of supplied and used energy; h) methodology for increasing the reliability of the calculation model of a building compared with actual energy use; i) a method for assessing the energy efficiency of possible improvements.	DBN B.2.6-31:2016 (partially) DSTU B V.2.2-39:2016 (partially) DSTU B V.2.2-21:2008 (partially)
BS EN ISO 13790 Energy performance of buildings. Calculation of energy use for space heating and cooling	These norms include the calculation: a) heat transfer when ventilation of the building area when heated or cooled to a constant internal temperature; b) the contribution of internal and solar heat to the	DBN V.2.6-31:2016 (partially); DSTU B V.2.2-

	thermal balance of the building; c) annual energy requirements for heating and cooling, as well as for maintaining the set room temperature; d) annual energy consumption for heating and cooling of the building using the relevant system standards specified in this standard.	21:2008 (partially); DSTU B. A. .2.2-12:2015
EN 15316-1 Energy performance of buildings. Method for calculation of system energy requirements and system efficiencies. General and Energy performance expression, Module M3-1, M3-4, M3-9, M8-1, M8-4	These norms include calculation: heat, mathematical calculations, efficiency, energy consumption, thermal power, thermal protection systems, heating equipment, buildings, systems of spatial heating, heat transfer, heat loss, hot water supply systems.	N/A
EN 15316-2 Energy performance of buildings. Method for calculation of system energy requirements and system efficiencies. Space emission systems (heating and cooling), Module M3-5, M4-5.	These norms include calculation: heat losses, hot water supply systems, energy saving, thermal protection systems, heating equipment, heat power, buildings, heat exchangers, heaters.	N/A
EN 15243 Ventilation for buildings. Calculation of room temperatures and of load and energy for buildings with room conditioning systems.	These standards include: a) Determination of the calculation procedure, calculation methods for temperature determination, reasonable loads and energy requirements for the premises to be used in the design process; b) Description of calculation methods for determining the hidden cooling and heat load for building heating, cooling, humidification, drainage and loading on these systems; c) Determination of the general approach for calculating the total energy efficiency of buildings with air conditioning systems; d) Determination of one or more simplified methods for calculating the energy needs of the system for specific types of systems based on demand and energy consumption of a building derived from EN ISO 13790 and determining their scope.	N/A
EN 15316-3 Energy performance of buildings. Method for calculation of system energy requirements and system efficiencies. Space distribution systems (DHW, heating	These standards include: heat losses, heating equipment, spatial heating systems, thermal calculation of buildings, thermal efficiency, energy consumption, mathematical calculations, central heating, heat exchange, thermal protection systems, hot water supply systems, efficiency, buildings.	DBN V.2.6-31:2016 (partially)

and cooling), Module M3-6, M4-6, M8-6.		
EN 15265 Energy performance of buildings. Calculation of energy needs for space heating and cooling using dynamic methods. General criteria and validation procedures.	These standards include: a) Evaluate the energy characteristics of each room in the house; b) Supply of energy data to be used as an interface for analyzing system performance (heating, cooling, ventilation, lighting, domestic hot water, etc.). The procedure is used to check the energy requirements for heating and cooling of premises based on the model of transitional sound thermal balance taking into account: - external thermal balance of the surface; - conductivity through the shell of the building; - thermal power of external and internal structures; - internal heat balance; - air heat balance; - methods for determining the thermal balance.	DSTU B V.2.6-37: 2008 (partially) DSTU B V.2.6-101: 2010 (partially) DSTU B V.2.6-189: 2013 (partially) DSTU B V.2.2-21: 2008 (partially)
EN 15193 Energy performance of buildings. Energy requirements for lighting.	These standards include: electrical measurements, performance, lighting systems, design, electrical power systems, energy consumption, lighting equipment, mathematical calculations, fixtures, power measurement (electric), electric lamps, buildings, electricity consumption, energy saving, indoor lighting.	DSTU B V.2.2-21: 2008 (partially)
EN 15241 Ventilation for buildings. Calculation methods for energy losses due to ventilation and infiltration in buildings.	This standard describes a method for calculating the energy impact of ventilation systems (including ventilation) in buildings, which will be used to calculate the thermal and cooling load. His goal is to determine how to calculate the characteristics (temperature, humidity) of air entering the building, and the corresponding energy required for its processing, as well as the required amount of electrical energy for the auxiliary devices.	DSTU B A.2.2-12: 2015 (partially) DSTU B V.2.6-37: 2008 (partially)
EN 15232 Energy performance of buildings. Impact of Building Automation, Controls and Building Management.	These standards include: control systems, efficiency, lighting systems, heat engineering, ventilation, thermal protection systems, air conditioning systems, automatic control systems, buildings, mathematical calculations, spatial heating systems, energy saving, productivity, energy consumption, heat calculation of buildings.	N/A
EN ISO 6946 Building components and building elements. Thermal resistance and thermal transmittance. Calculation methods.	These norms include: heat transfer, thermal conductivity, mathematical calculations, thermal balance of buildings, buildings, thermal insulation, thermal stability, details of building systems.	DSTU B V.2.6-100: 2010 (partially) DSTU B V.2.6-101: 2010 DSTU B V.2.6-189: 2013
EN ISO 13370 Thermal performance of buildings. Heat transfer via the ground. Calculation methods.	These norms include: physical properties of soils, temperature, soil, equation, floor, floor boards, formulas (maths), thermal insulation, cellars, thermal properties of materials, heat measurements, thermal behavior of structures, thermal resistance, heated floors, heat	N/A

	transfer , climate, hanging floors, thickness, ventilation, heat transfer coefficient, refrigerating chambers, groundwater, dimensions, mathematical calculations, thermal conductivity, thermal bridges.	
EN ISO 10077-1 Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. General.	These standards include: double-glazed windows, doors, thermal design of buildings, mathematical calculations, window frames, windows, blinds (buildings), details of building structures, thermal insulation, glazing, doors, window glass, thermal conductivity.	DSTU B.2.6-XX: 200X (partially) DSTU B V.2.7-107: 2008 (partially)
EN 13947 Thermal performance of curtain walling. Calculation of thermal transmittance.	These standards include: buildings, curtains, lining (buildings), building components, thermal conductivity, glazing, glass, heat transfer, mathematical calculations, thermal bridges, thermal calculation of buildings, thermal insulation.	N/A
ISO 10077-2 Thermal performance of windows, doors and shutters. Calculation of thermal transmittance. Numerical method for frames.	These standards include: frame for slots, door frames, glazing, windows, mathematical calculations, roller shutters, specific heat conductivity, parts of building systems, doors, door block (door with door box), thermal measurements, window frame, heat transfer, thermal conductivity .	N/A
EN ISO 14683 Thermal bridges in building construction. Linear thermal transmittance. Simplified methods and default values.	These standards include: classification of systems, constraints, heat transfer, parts of building structures, thermal conductivity, buildings, heat transfer, mathematical calculations, heat calculation of buildings, definitions, thermal bridges, linearity, construction work.	DSTU B EN 13187: 2011 (partially)
EN ISO 10456 Building materials and products. Hygrothermal properties. Tabulated design values and procedures for determining declared and design thermal values.	These standards include: building materials, buildings, thermal calculation of buildings, thermal properties of materials, specific thermal conductivity, heat resistance, homogeneity, change, temperature, material aging, humidity, thickness, test conditions, calculations, statistical methods of analysis.	N/A
EN 15242 Ventilation for buildings. Calculation methods for the determination of air flow rates in buildings including infiltration .	These standards include: air flow, ventilation equipment, buildings, air flow measurements, mathematical calculations, heat shrinkage systems, ventilation, air conditioning systems, mechanical ventilation, air, and productivity.	DBN V.2.6-31: 2006 (partially) DSTU B V.2.2-19: 2007 (partially)
EN 13779 Ventilation for non-residential buildings. Performance requirements for ventilation and room-conditioning systems.	These standards include: heat shrinkage systems, air, system classification, thermal design of the building, thermal comfort, quality, air conditioning systems, ventilation, air conditioning equipment, ventilation equipment, efficiency (productivity), buildings, operating conditions, energy consumption .	N/A
EN 15251 Indoor	This standard specifies indoor environmental conditions	N/A

environmental input parameters for design and assessment of energy performance of buildings addressing indoor air quality, thermal environment, lighting and acoustics.	in buildings that affect the energy efficiency of buildings: - How to set the internal input parameters of the environment to calculate building design and energy efficiency. - Methods for the long-term assessment of the internal environment, obtained as a result of calculations or measurements. - measurement criteria that can be used if a compliance check is required. - determines the parameters that will be used to monitor and display the internal environment in existing buildings. This standard is applicable mainly to non-industrial buildings, where the criteria for the internal environment are established by the person and the production process does not significantly affect the internal environment. The standard can thus be applied to the following types of buildings: single-family houses, apartment buildings, offices, educational institutions, hospitals, hotels and restaurants. The standard specifies how to use different categories of criteria for the internal environment. But their use is not unconditional and depends on national rules or specifications of individual projects. The recommended criteria in this standard may also be used in national calculation methods that may differ from the methods described herein. The standard does not design design methods, but gives the water parameters for designing buildings, heating, cooling, ventilation and lighting. The standard does not include criteria for local discomfort factors such as sediment, asymmetry of the radiant temperature, vertical air temperature difference and surface temperature	
EN ISO 15927-5+A1 Hygrothermal performance of buildings. Calculation and presentation of climatic data. Data for design heat load for space heating.	These standards include: maintenance of buildings, equipment of thermal systems, systems of spatial heating, climatic loading, humidity, windows, speed, methodology of determination and measurement, design of heat communications, thermal protection, heat calculation of a building.	N/A
EN ISO 7345 Thermal insulation. Physical quantities and definitions.	These norms include: units of measurement, definitions, symbols, terminology, thermal properties of materials, thermal insulation, thermal conductivity.	ДБН В.2.6-31:2016 ДСТУ Б В.2.6-34:2008
EN ISO 9288 Thermal insulation. Heat transfer by radiation. Physical quantities and definitions.	These norms include: units of measurement, definitions, symbols, terminology, thermal properties of materials, thermal insulation, thermal conductivity.	N/A

EN 12792 Ventilation for buildings. Symbols, terminology and graphical symbols	These standards include: ventilation, terminology, symbols, graphic symbols, buildings, air conditioning systems, air conditioning equipment, ventilation equipment.	N/A
EN 15378 Heating systems in buildings. Inspection of boilers and heating systems.	These standards specify the procedures and additional measurement methods that will be used to check and assess the energy performance of boilers and heating systems.	N/A
EN 15240 Ventilation for buildings. Energy performance of buildings. Guidelines for inspection of air-conditioning systems.	These standards include: thermal protection systems, ventilation equipment, maintenance, energy consumption, air conditioning systems, cooling, air conditioning equipment, inspection, buildings, heating, productivity, ventilation.	N/A
EN 15239 Ventilation for buildings. Energy performance of buildings. Guidelines for inspection of ventilation systems.	These standards include: ventilation, ventilation equipment, ventilation ducts, air, energy saving, power consumption, mechanical ventilation, buildings, control systems.	N/A
Sustainability of building		
ISO 15392:2008 Sustainability in building construction -- General principles	This standard identifies and establishes general principles for sustainability in building construction. It is based on the concept of sustainable development as it applies to the life cycle of buildings and other construction works, from their inception to the end of life.	N/A
ISO 21929-1:2011 Sustainability in building construction -- Sustainability indicators -- Part 1: Framework for the development of indicators and a core set of indicators for buildings	This standard establishes a core set of indicators to take into account in the use and development of sustainability indicators for assessing the sustainability performance of new or existing buildings, related to their design, construction, operation, maintenance, refurbishment and end of life. Together, the core set of indicators provides measures to express the contribution of a building(s) to sustainability and sustainable development. These indicators represent aspects of buildings that impact on areas of protection related to sustainability and sustainable development.	N/A
ISO/TS 21929-2:2015 Sustainability in building construction -- Sustainability indicators -- Part 2: Framework for the development of indicators for civil engineering works	This standard establishes a list of aspects and impacts which should be taken as the basis for the development of sustainability indicators for assessing the sustainability performance of new or existing civil engineering works, related to their design, construction, operation, maintenance, refurbishment and end-of-life. Together, the indicators developed from this list of aspects and impacts provide measures to express the contribution of a civil engineering works to sustainability and sustainable development. The developed indicators should represent aspects of civil engineering works that impact on issues of concern related to sustainability and sustainable development.	N/A

ISO 16745-1:2017 Sustainability in buildings and civil engineering works -- Carbon metric of an existing building during use stage -- Part 1: Calculation, reporting and communication; Part 2: Verification	This standard provides requirements for determining and reporting a carbon metric of an existing building, associated with the operation of the building. It sets out methods for the calculation, reporting and communication of a set of carbon metrics for GHG emissions arising from the measured energy use during the operation of an existing building, the measured user-related energy use, and other relevant GHG emissions and removals. These carbon metrics are separated into three measures designated CM1, CM2, and CM3	N/A
ISO 21930:2017 Sustainability in buildings and civil engineering works -- Core rules for environmental product declarations of construction products and services	This standard provides the principles, specifications and requirements to develop an environmental product declaration (EPD) for construction products and services, construction elements and integrated technical systems used in any type of construction works.	N/A

Voluntary standards of environmental assessment of buildings according to the sustainability principles. The principles of "green" construction presuppose the application of a certification system developed on the basis of the concept of sustainable development, taking into account national particularities. For most of the countries of the post-Soviet space, support for the global trend in the development of the construction industry in accordance with "green" standards is becoming more urgent due to the need to address such actual problems as high dependence on fuel and energy resources, irrational use of land resources, shortage of affordable quality housing, low energy efficiency of the existing housing stock.

Among the problems and peculiarities of certification of construction objects for compliance with the standards of sustainable development were scientists such as Granev V.V. [2], Zhurba A.O. [3], Kozharinov A.V. [4], Matrosov Yu. A. [5], Naumov A.L. [6], Primak L.V. [7], Sukhinina E.A. [8], Tabunshchikov Yu.A. [2], Rob Watson [8], etc. In different countries of the world Eco-certification has become so popular that environmental standards are considered mandatory for many types of buildings.

At the same time, in Ukraine, construction that meets the standards of sustainable development has been extended so far only at the level of individual developers. Despite the creation of the Council for Green Building and the development of a number of government programs aimed at improving energy efficiency in the

housing and communal sector, Ukraine does not have a national system for the environmental certification of construction sites, and the development and implementation of such standards in the country have not been received necessary dynamics. As a result, the principles of "sustainable development" and "green building" have not been integrated into the national construction practice for now.

From the perspective of a modern understanding of sustainable development, environmental requirements should be met by all the components of the construction site, including the building, territory and the consequences of human impact on the environment.

The ecological characteristics of the building can be assessed by the criteria of "green" standards designed to ensure the transition from traditional design and construction to a balanced (sustainable, "clean"), which implies the following principles: safety and favorable healthy conditions for human life, limiting the negative impact on the environment, consideration of the interests of future generations.

On the one hand, the variety of systems for the environmental certification of construction sites is justified by the differences in the conditions under which they are implemented - geographic location, climatic conditions, the level of development of construction technologies, the market of materials and services, etc. However, rating systems with a different set of criteria create certain difficulties for stakeholders, including investors who buy buildings in different countries.

All existing systems of environmental certification of the building, taking into account the number of certified facilities and their geography, can be conditionally divided into global distribution systems and the systems of national importance.

The group of global rating systems include the LEED standard (USA) and the BREEAM standard (UK), which have the following features:

• these standards were adopted as national standards in many countries or formed the basis of national rating systems;

• according to these standards, more objects are certified than other rating systems;

• these standards have become widespread and popular.

The national rating system includes all national standards, for example, German standard DGNB, French HQE, Danish EcoProfile, Japanese CASBEE, Canadian GBI, Russian Green Standards.

In recent years, based on the standards of sustainable development in construction, they have started to create software packages for the assessment of the environmental parameters of the project (BEES - Building for Environmental and Economic Sustainability).

Voluntary assessment of buildings according to the sustainability standards in Ukraine. In Ukraine, at the state level, numerous laws have been adopted and draft laws have been drafted aimed at energy saving in construction. However, up to now, there has not been developed a national voluntary system for assessing buildings in accordance with the standards of sustainable development, taking into account the life cycle - from the project of the construction site to the utilization of building materials.

The "green" standards are based on the Life Cycle Assessment (LCA) method, which includes the following stages: extraction of raw materials, natural materials, processing of materials, production of goods, transportation and distribution, use, maintenance, processing, reuse and disposal waste.

Based on the analysis of foreign experience of the LCA method, the Ukrainian system of voluntary environmental certification of construction objects is proposed, which is harmonized with the world standards of sustainable development. Its tasks are:

• Minimization of the negative impact of the property on the environment;

• minimization of environmental pollution by real estate objects - both during construction and operation;

• rational use of natural resources necessary for the construction and operation of real estate;

• Introduction of advanced energy-efficient technologies into the practice of construction and operation of buildings and structures;

• Promotion and promotion of the development of green building in Ukraine;

• Assistance to buyers in the competent choice of real estate objects that do not have a negative impact on the environment.

The following construction sites are subject to certification:

• land plots - a part of the earth's surface (including the soil layer), the boundaries of which are described and fixed in the established order;

• new buildings and structures - capital construction facilities that have load-bearing and enclosing or combined structures forming a closed volume;

• objects of construction in progress - a building or structure for which documents on the commissioning of the facility have not been issued in accordance with the established procedure;

• operated buildings and structures - capital construction facilities in operation;

• social complexes and settlements - an administrative-territorial unit, united by one territory, infrastructure, social orientation;

• internal premises - objects that are part of buildings and structures.

Formation of environmental requirements for construction sites is the rational use of natural resources, minimizing the negative impact of economic activities on the environment, providing favorable conditions for human life and its self-realization.

In existing systems, one of the priority criteria is energy efficiency, which is mainly achieved and evaluated through the use of high-tech energy-saving equipment, which increases the cost of initial investment in construction. In the conditions of Ukraine, the use of such equipment is difficult because of its high cost.

Since the indicator of the energy efficiency class is one of the most important criteria for compliance with the standards of sustainable development, it was suggested that the developed system assess it with indicators of the effective use of local renewable materials of organic origin with high thermal characteristics and the use of rational architectural and constructive solutions. The energy efficiency class is assessed in accordance with the current Ukrainian standards, whose requirements and method of classification are generally comparable with world standards.

In the proposed system of certification of construction objects, the criteria for sustainable development are determined by the combination of the following indicators: innovative management, site selection, efficient use of natural resources, integration architecture, materials and structures, organization of internal space, operational waste,

energy efficiency, economic efficiency and socio-cultural organization.

Innovative management is assessed both at the design stage, and during the implementation of the project, operation and disposal of the construction site. At the design stage, the thermophysical and energy characteristics of the facility, the environmental friendliness of materials, and the optimization of the economic performance of the facility, taking into account the life cycle, are taken into account. For the analysis of these indicators, the project documentation and data received from the developer are studied.

At the stage of the construction project, the following parameters are taken into account: construction of a building site in accordance with environmental requirements for the construction process, minimization of waste during construction work (secondary processing or use of waste); informing citizens about the main indicators of the property, carrying out measures to protect and restore the environment in the process of construction (conservation of the soil layer, recycled water supply, dust suppression, regulation current storm water collection in a single place, wastewater treatment, protection of stem and root system of trees and shrubs, portion reduction with fertile soil).

To assess the environmental impact of the facility during its operation, visual monitoring is used, which includes the analysis of a certain set of indicators, including the use of environmentally friendly fertilizers for gardening, cleaning products, anti-icing agents, the refusal to use mercury-containing lamps, the availability of environmental certificates for engineering equipment object. In addition, at all stages of the building's life cycle, qualified environmental monitoring is carried out, which allows to increase the environmental performance of the building due to timely professional analysis and adjustment.

When **choosing the site** of the construction, the environmental quality is assessed, including the degree of pollution of soil, air, water sources, the effects of electromagnetic radiation, the risks of man-caused impacts and hazardous natural phenomena, the degree of planting of the territory, insolation of the adjacent territory, the protection of the territory from noise, vibration , infrasound, other indicators in

accordance with current standards and norms of Ukraine. It also assesses the possible impact of urban development on the existing ecosystem - indicators of the effective use of natural resources and the integration architecture.

Analysis of the **efficiency of the use of natural resources** in such parameters as the reduction of the water consumption per person per year in relation to the standard, the separation of water supply into technological and drinking water, the availability of wastewater reuse systems for toilets and urinals, the collection of rainwater, their purification and use in system of technological water supply, collection of rain water for irrigation of the adjacent territory, accounting of water consumption at the end user, availability of water-saving drain tanks, shower grids, mix Lei, the use of secondary and renewable energy. The given criterion allows to estimate all systems of the building object aimed at energy saving and rational use of available natural resources on the site.

The level of **architecture integration** is evaluated expertly, including the analysis of the quality indicators of the architectural appearance of the facility, its correspondence to the surrounding buildings, functional purpose, originality, architectural perfection, aesthetics. In addition, at the design stage, an assessment should be made of the optimality of the chosen architectural form of the object and its orientation, which are designed to provide the best energy performance, comfort of space-planning solutions (overall indoor indices), natural lighting possibilities, planting of greenery ("winter garden" , vegetative roof, elements of vertical gardening).

The general level of environmental friendliness of the facility is fundamentally affected by the use of **building materials** of natural origin, especially those that are certified as ecological. The quality of materials is assessed for compliance with one of the main criteria of sustainable development - waste minimization and the possibility of their complete reutilization.

Particular attention in assessing the ecological compatibility of the building is paid to the indicators of the organization of the **internal space**. Including air-thermal comfort can be controlled due to the planned measures to optimize the microclimate parameters - temperature, humidity, air exchange, air speed. No less important is light comfort, which is estimated by the degree of compliance with the standards for

illumination, the presence of automatic control of artificial lighting or complex LED lighting. Special measures to reduce noise ensure the organization of acoustic comfort in the room, which is especially important in urban development and in the design of apartment buildings and public buildings. Olfactory comfort should be provided both by ventilation systems and by the use of non-toxic materials without sharp odors. An important indicator of the environmental security of a room for a person is the security of the premises from the accumulation of radon.

The next criterion for assessing the environmental friendliness of the facility is the level of **operational waste** - the quality of the organization of collection / disposal of waste and sanitary protection of the facility. It should be noted that to date, the organization of the primary sorting of waste, which is specified in government regulations, has not yet been integrated into the practice of public services for the residential sector. The proposed project provides an indicator of the level of utilization of operational waste, which significantly enhances the environmental friendliness of the facility. The quality of sanitary protection is ensured by the tightness of the garbage chutes and compartments with autonomous mechanical ventilation, the presence of an automated system of antibacterial treatment and an automated system of protection against the rodents and insects of garbage chutes, pantries, cellars, etc.

In the energy and economic realities of Ukraine, one of the key indicators of the environmental friendliness of the facility should be to ensure the **energy efficiency** of construction projects. Energy efficiency is understood as the rational use of energy resources, i.e. use the minimum possible amount of energy to provide the same level of energy supply to buildings or technological processes. The criterion proposes to estimate the cost of heat energy for heating and ventilation in accordance with the energy efficiency class in accordance with current standards; Expenses of thermal energy for hot water supply; electricity costs for lighting, engineering support systems, air conditioning systems, application of LED lighting sources, installation of electrical equipment with a high energy consumption class with the appropriate marking. The presence of a centralized control system of the facility with the possibilities of zonal regulation of the local engineering support system allows monitoring energy efficiency

indicators, which improves the overall environmental performance of the facility.

An important indicator of the environmental friendliness of the facility is its **economic efficiency**. This indicator is estimated by the ratio of the investment value of the object to the cost of a similar facility that meets the minimum established requirements, and the ratio of the average annual cost of operating the facility to similar costs for a traditional analogue facility.

The **socio-cultural organization** is assessed from the point of view of the reach of the objects of the social and domestic infrastructure necessary for the normal provision of vital functions for people (health care institutions, trade points, passenger transport, banking and postal services, catering, household and communal services, etc.). Particular attention in assessing this criterion should be given to guarantees of accessibility of services for the low-mobility population groups. Estimation of the property's compliance with environmental requirements is carried out by direct comparison of project indicators (or a finished building) with existing standards and standards.

According to the proposed methodology, each score indicator is put a score, which is then summed according to the criterion and by group of criteria. The resulting amount is multiplied by 100% and is divided into the highest possible total score. As a result, the estimated score for the object is calculated.

As a result of certification one of the four types of certificates can be assigned, provided all the necessary requirements have been fulfilled and the total points obtained from the maximum possible score have been achieved (see Table 2).

Table 2.

Proposed certificates for compliance with the level of environmental friendliness of construction sites

Certificate	**Somme of points, %**
Certified for sustainability requirements	40 – 49
Silver	50 – 59
Gold	60 – 80
Platine	More 80

Conclusions:

1. An analytical review of more than 25 current Ukrainian standards in the field of energy efficiency and environmental housing design for compliance with European analogues and standards of sustainable development has been carried out. Those European standards that today have no analogues in Ukrainian norms, but are important in the development of sustainable buildings projects are highlighted.

2. Based on foreign experience and in accordance with Ukrainian national norms, a system for assessing the environmental performance of construction sites was proposed and registered as the corporative standard at SHEI "Prydneprovska State Academy of Civil Engineering and Architecture".

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