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**Improving ecological safety of heat-and-cool-supply systems in buildings by balanced use of alternative and traditional energy sources.**

**The problem considered in the paper.** Transition to alternative energy sources - wind, solar, geothermal, biomass - can, on the one hand, refuse imports of energy and provide consumers with flexible local power plants, on the other hand, what is the most important thing - significantly reduce pollution. Effective implementation of wind and solar energy in heat-and-cool-supplying systems of buildings can't be done without defining optimum combination of these alternatives to existing conventional energy sources.

The scientific approach to solving this problem, of course, requires a gradual replacement of traditional energy resources to their optimal value.

**Analysis of previous research** in the field of theoretical bases of environmental safety assessment [1, 2, 3, 4], the use of wind and solar energy in heat-and-cool-supply systems [5, 6, 7], approaches to modelling of energy flows in alternative power supply systems [8, 9 10] identified the main threats to environmental safety resulting of operation of traditional heat-and-cool-supply systems.

Based on a combination of alternative and traditional energy within the concept of "Green buildings" [11, 12] a mathematical model and automatic energy management of buildings were created. However, they can only evaluate energy

efficiency, not giving the assessment of environmental safety in complex heat-and-cool-supplying systems with using of alternative and traditional energy sources. The developing of these problem aspects of increasing environmental safety of heat-and-cool-supplying by optimal redistribution of power between alternative and traditional sources are certainly relevant and timely.

**Aim of research** is to develop a method of optimizing the parameters of heat-and-cool-supplying in terms of ecological safety index and solving an optimization problem on the example of heat-and-cool-supplying of single residential building.

**Basic material.** The researcher worked out the method of complex evaluating the environmental safety of heat-and-cool-supplying systems based on the index and expressed through grounded indicators considering versatile environmental impact aspects and intensity of different types of technogenic influence on a human. In order to develop a mathematical model of energy redistribution between renewable and conventional sources offer an alternative system based on wind and solar energy with compensation of energy shortage by conventional sources.

Created mathematical model is based on redistribution of wind and solar energy between hot-water-supplying, heating, cooling and water treatment with a maximum level of substitution of traditional resources by renewables. Based on the developed mathematical model, the objective function of optimization of ecological safety index of heat-and-cool-supplying is:

$$\begin{aligned}
 IEB(A, D, V_{AK}) = & \\
 = 1 - \frac{k}{\sum_{j=1}^k} \left[ \frac{1}{n} \sum_{i=1}^n \left( \frac{A \cdot (I_i \cdot \eta_0 - K(T_{BXi} - T_{HCi})) \cdot P_i + Cp_s \cdot \frac{\rho_n \cdot v_i^3}{2} \cdot \frac{\pi \cdot D^2}{4} \cdot \eta_{el} \cdot \eta_{mex} \cdot \eta_{es} \cdot t_i -}{\left[ \sum_{i=1}^n K_n \cdot F_n + r \cdot L \cdot c_n \cdot \rho_n \cdot k \right] \cdot (T_{\theta n} - T_{HCi}) \cdot t_i + q_{\theta m} \cdot F_{ni\theta l} \cdot t_i + N \cdot g_i \cdot c_{\theta} \cdot \rho_{\theta} \cdot (T_{z\theta} - T_{X_i}) \cdot (1 + \beta) \cdot t_i} \right. \right. & \\
 - K_{AK} \cdot A_{AK} \cdot \left( \frac{A \cdot (I_i \cdot \eta_0 - K(T_{BXi} - T_{HCi})) \cdot P_i + Cp_s \cdot \frac{\rho_n \cdot v_i^3}{2} \cdot \frac{\pi \cdot D^2}{4} \cdot \eta_{el} \cdot \eta_{mex} \cdot \eta_{es} \cdot t_i -}{V_{AK} \cdot \rho_m \cdot c_m} \right. & \\
 \left. \left. \frac{\sum_{i=1}^n K_n \cdot F_n + r \cdot L \cdot c_n \cdot \rho_n \cdot k \right] \cdot (T_{\theta n} - T_{HCi}) \cdot t_i + q_{\theta m} \cdot F_{ni\theta l} \cdot t_i + N \cdot g_i \cdot c_{\theta} \cdot \rho_{\theta} \cdot (T_{z\theta} - T_{X_i}) \cdot (1 + \beta) \cdot t_i}{V_{AK} \cdot \rho_m \cdot c_m} \right) \right) & \quad (1) \\
 - \left[ \frac{\sum_{i=1}^n K_n \cdot F_n + r \cdot L \cdot c_n \cdot \rho_n \cdot k \right] \cdot (T_{\theta n} - T_{HCi}) \cdot t_i + q_{\theta m} \cdot F_{ni\theta l} \cdot t_i + N \cdot g_i \cdot c_{\theta} \cdot \rho_{\theta} \cdot (T_{z\theta} - T_{X_i}) \cdot (1 + \beta) \cdot t_i}{V_{AK} \cdot \rho_m \cdot c_m} + T_{xm} - T_{\theta n} \right) \cdot t_i & \\
 \times \frac{\phi_{j-A}}{\phi_{j-T}} \cdot d_j \rightarrow \max &
 \end{aligned}$$

In the practical part of the research the ecological safety indices for different types of systems in climatic conditions of Southern region were simulated mathematically. The optimization task of heat-and-cool-supplying on the example of particular residential building was solved. The opportunity of improving the ecological safety of existing in Mykolaiv region systems by equipping them with wind and solar plants was assessed.

Simulation results show that accounting of energy flows redistribution can increase the level of environmental safety of an alternative system by 35%; and the use of optimal solution makes it possible to increase the index of environmentally friendly alternative system compared with traditional coal-burning by 63%.

Using of renewable energy in systems of heat-and-cold-supply will reduce air pollution by 43-66% and the volume of generated solid waste by 46-62% compared with traditional system based on electricity produced by coal-generating plant (as the worst option).

Results of the study of environmental safety index when introducing wind and solar installations into existing systems in different places of Mykolaiv region (Bashtanskiy, Vosnesenskiy, Mykolayivskiy, Ochakovskiy, Pervomayskiy) showed the possibility of its increasing by 50-55%.

**Conclusions.** Grounded index allows evaluating the environmental safety of heat-and-cool-supplying systems based on the index and expressed through grounded indicators considering versatile environmental impact aspects and intensity of different types of technogenic influence on a human. Created mathematical model allows optimizing the volumes of substitution of conventional sources and the balance of the various renewable sources in terms of environmental safety index by 15-35% in Southern Ukraine. Created algorithm of increasing the environmental safety of heat-and-cool-supplying by redistribution of wind and solar energy between subsystems of hot water, heating, air conditioning and water treatment with a maximum level of substitution the traditional resources by alternative and full using the excess energy produced by alternative sources provides more efficient use of renewables by 15-20%.

**Stoyan O.** (Mykolaiv).

#### **Improving state regulation mechanisms of renewable power development in Ukraine within the context of environmental security.**

Analysis of major trends and changes in the nature of environmental safety factors of Ukraine proves that maintain high energy and capacity resources of economy of Ukraine in case of further depletion of land, water, mineral and biotic resources will inevitably lead to the formation of large-scale threats to national security in the environmental and natural-technogenic fields. A recent geopolitical developments demonstrate that energy efficiency and renewable energy sources (hereinafter - RES) - this is probably the only real way of ensuring energy and environmental security of Ukraine, which will help keep afloat the economy and industry.

Given the fact that the effective use of renewable energy is possible only with the condition a targeted state support renewable energy particular in Ukraine, cannot fail to stress the need and importance of research and further improving of state regu-

lation renewables Ukraine in the context of ensuring of ecological security of Ukraine.

In our opinion, more in line to objective of this research and the context of concepts economic security, the idea of environmental security as a backbone element of national security, because of the set of properties of the state of its subsystems provides the ability to achieve the objectives of the entire national security system.

Note that among the key benefits of renewable energy are a significant reduction of pollutant emissions, compared to conventional energy sources, particularly greenhouse gas emissions, a more uniform distribution of energy resources, decentralization of energy production, increase economic freedom of the country, which is one of the main conditions for ecological and energy security of Ukraine. In addition, the cost of energy produced from renewable energy sources, already below the cost of energy from traditional sources, as prices for renewable energy are reduced, while for traditional - is constantly growing. So, given the above, there still remains highly topical issue of the use of renewable energy as ecological and most effective way to solve these problems.

Key points of government policy and of the development of mechanisms of state regulation of renewable energy of Ukraine in the context of providing environmental security require improvement, particularly in the following areas: implementation of an effective system of monitoring emissions; creation of a system of state subsidies for renewable fuels and renewable energy technologies; formation of partnerships between government and the industrial business; targeting the state government on support enterprises which implement renewable technologies; the creation of a new state system for monitoring the consumption of resources and use of renewable energy by enterprises; improvement of legislation in the area for granting permissions to approaching European standards and requirements. First of all fixing legislative, and not in the form regulative acts the legal foundations of production based on renewable energy; prohibiting the production or use of hazardous substances with a high degree of risk; carrying out modernization and introduction of new cleaner technologies for renewable energy; the realization of revaluation methods of reimbursement of damages caused by violation of legislation on protection and rational use of natural resources to compensate for such losses in full; establishment of a State's system of financial support in the implementation of energy saving technologies using renewable energy in all spheres of the economy and implementation of performance monitoring and subsequent financial control over the targeted use of this funds; approval of the National plan of action for the development of renewable energy sources; implementation of legal framework regarding the use of renewable energy and environmental protection, as well as the improvement of legislation on granting permits for air emissions, discharges to the water of pollutants and waste disposal in accordance with EU directives and other policy documents of the EU.

The implementation of the written above steps will give the opportunity to implement an effective mechanism for the implementation of the government's policy of encouraging and development of renewable energy of Ukraine and will create

conditions to ensure environmental and energy security by increasing the amount of renewable energy and alternative fuels.

**Rokhman B.** (Kyiv).

**On the steam-oxygen gasification of the coke-ash particles of brown and black coal in a fluidized bed under pressure.**

A kinetic equation for the distribution function of particles by carbon concentration in the fluidized bed, which correctly describes the thermochemical processes of the steam-oxygen gasification of the coke-ash residue in the diffusion, kinetic and transition regions of reaction is derived. Boundary conditions ("linking" conditions), and analytical solutions for the distribution function of particles in small intervals of the carbon concentration changing for surface and volume patterns of reaction are formulated. On the basis of analytical expressions the method of calculation of aerodynamics and physicochemical processes in fluidized bed taking into account heterogeneous and homogeneous reactions, radiative and conductive-convective heat transfer is developed. With the help of the developed model theoretical studies of steam-oxygen gasification of certain types of solid fuels such as gas coal of brand GSSh (Dobropol coal mine, Donbass) and brown coal of brands B1 (Dnepropetrovsk basin) and B2 (Kansk-Achinsk basin), and binary mixtures of coal are conducted. The influence of the particle size distribution of raw coal, its ash content, height, porosity and temperature of the bed on the mechanical incomplete combustion in a fluidized bed is studied.

It is shown that:

a) increasing the weight of the bed and the rate constants for heterogeneous reactions by increasing the height of the bulk layer, its temperature and reducing the porosity contributes transition of coke-ash particles from high-carbon to low-carbon region, whereby mechanical incomplete combustion is reduced;

b) coarsening of raw coal particles reduces the rate of carbon conversion, thereby increasing the mechanical incomplete combustion;

c) the height of the bed can be divided into three zones. The first is characterized by a sharp decrease in oxygen concentration due to the conversion of carbon and burnout of gasification products. In the second (anoxic) zone steam conversion rate of carbon significantly prevails over the rate of reaction of coke with carbon dioxide. In the third zone, wherein the content of  $H_2O$  и  $O_2$  in the gas mixture is negligible, coke-ash residue gasification is carried out mainly by the reaction of  $C + CO_2 = 2CO$ ;

g) with steam-oxygen gasification of a binary mixture consisting of 70% of the GSSh particles and 30% of the brown coal B1 particles, carbon conversion level of the large fractions of gas coal is lower than that of brown coal due to higher values of activation energy of heterogeneous reactions in gas coal;

d) an increase in the ash content of coarse fractions of raw gas coal and brown coal of brand B1 enhances mechanical incomplete combustion in a fluidized bed.

**Bud'ko V.** (Kyiv).

**Studying parallel operation modes of ecomobile traction power supplies.**

The ecomobile combined power source (traction battery – PV unit – diesel engine) testing has been performed under different modes of operation, namely:

- Standard city cycle(SAEJ 227);
- Various constant speed runs;
- Delivery service with prolonged stops.

The obtained testing data analysis has shown that the traction battery charging is possible either at joint operation of PV unit and diesel engine or with only one of these running. In view of the fact that PV unit capacity increases in direct proportion to its area with vehicle dimensions being a controlling factor the adequate boost charge of traction batteries is possible during frequent an prolonged stops of the ecomobile. The most reliable and rational charging of batteries can be achieved under stationary conditions.

**Ryetzov V., Surzhik T., Shchokina V.** (Kyiv)

**The model of unstable changes average temperature moisture contain mediums in the solar drying processes.**

Solar drying is one of the natural processes of interaction of radiation solar energy with the moisture contain mediums which leads to the formation of spatially inhomogeneous structures on the surface and in the bulk medium. This processes are attended by unstable changes of the temperature moisture contain mediums? So actually to consider the changes in the average temperature on the surface and in the bulk of the moisture contain medium and analyze the fluctuations average temperature of the consequent of changing the power of solar radiation? Ambient temperature changes and thermodynamic characteristics using the integral theorem of vector analysis about the divergence.

In the article shows the use of the integral theorem of vector analysis about the divergence for getting the differential equation for average bulk temperature moisture contain mediums at the solar drying? On which is obtained ordinary differential equations for average bulk temperature moisture contain mediums on the solar drying with the considering convective heat transfer and filtering moisture.

Developed the approach to the characterization of the steady state, dynamics changes average temperature over the time with analysis of classical theorem of resistance and also offered a method of analysis fluctuation of the average temperature due to fluctuation power solar radiation, ambient temperature fluctuation and thermodynamic characteristics which is determine the heat exchange moisture contain mediums with the environment.

**Ryetzov V., Kuchinsky V., Surzhyk O., Kokoshyn S.** (Kyiv).

**Features of temperature field distribution on the surface of photovoltaic and photothermal modules under various heat withdrawal terms.**

As setting of photocells plates on a compo panel heat removing realizing her accommodated collector with force aquatic cooling. In this case the temperature field of a photo-thermic module practically does not depend on the parameters of environment (temperature, wind, fallouts) and determined only by the construction of elements of panel and terms of heat removing. These terms can plug in itself both the possible changes of expense of coolant (up to its complete freezing) and probability of corking of one or a few tubes of collector. Thus determination and analysis of the temperature field of panel at the different terms of heat removing are an actual task at development of construction elements and operating descriptions of photo-thermic module. In the article with the use of method of eventual

elements the analysis of distribution of the temperature field of panel of a compo photo-thermic module is executed at different heat removing terms. The introduced construction of the photo-thermic module considered allows to get both electromotive force and thermal stream from 12 to 20 liters per hour of hot water with a temperature from 60 to 45 degrees respectively. Absence of heat removing (i.e. corking) of one of four consistently located tubes of introduced collector is assumed. In case of stopping of serve of coolant in all tubes of the collector it is recommended to delete of a translucent isolation and conduct further exploitation of photo-thermic module in the mode of the photo-electric module.

**Ushkalenko O., Gaevsky A.** (Kyiv).

#### **Statistical forecasting of solar radiation based on satellite images. the "displace" algorithm**

Solar electricity produced by PV plants is expected to contribute major shares of the future global energy supply. Due to fluctuating nature of renewable energy sources any efficient implementation of PV power has to account the respective operating strategies which based on solar irradiance forecasting. Many approaches to forecasting of global irradiance in various time and spatial scales have been developed. They may be broadly characterized as *physical* or *statistical*. The physical approach uses solar radiation and PV models to generate PV forecasts, whereas the statistical approach relies on historical data and statistical analysis. The statistical approach slightly outperformed the physical one to short-term forecasts and conversely the physical approach is preferable to long-term forecasts. In practice, however, these two approaches can be blended and the division between them is not sharp.

In this article the statistical forecasting approach based on the satellite imagery analysis and cloud motion calculation is used. Satellite imagery is commonly considered the best forecasting technique up to 5 hours because of excellent temporal and spatial resolution of satellite data [4 – 7]. To produce future cloud images, pixel intensities from the latest satellite image are adverted using the calculated cloud displacement vectors. But the reconstruction problems appear in areas where neighbouring displacement vectors are significantly different. The use of a semi-Lagrangian displacement vectors rather than the original ones improves the trajectory forecasts and reconstruction image procedure [8], but requires a large amount of computation. In this paper we propose a different method, called the "ousting" method, which in accuracy is not inferior to the semi-Lagrangian and consumes less calculation time.

The proposed method provides a root mean square error (RMSE) 13-15 % for forecasting horizons 15-75 minutes and for rather uniform clouds. It should be mentioned that forecast error strongly depends from block sizes into which the image is divided under correlation determination. The minimal RMSE error value is reached when block size lies between  $9 \times 9$  and  $11 \times 11$  pixels. To optimize the procedure of eliminating a large mismatch between neighbouring vectors, we performed the selection and setting appropriate filters (median, mean value and Gaussian). The most precise forecasts were obtained with median filter and convolution matrix  $15 \times 15$  pixels.

**Kuznetsov M.** (Kyiv).

#### **Modelling capacity peculiarities for wind farms located in a restricted area.**

An important feature of wind power is its uncontrolled energy, which leads to random changes of current capacity and may have a negative impact on the stability of the grid. Needs in additional spare capacity under different variants of the wind farms implementation can be determined using adequate mathematical model. Current value of grid power appears as random process, where daily, weekly and annual periods are clearly observed. Therefore, the modelling of the power system should be run on different time scales that take into account both cyclical nature and operating speed of reserve stations. In mathematical modelling of grid its current power usually has an averaged component (trend line) according to the season, and a stochastic component describing the irregular power changes throughout the day. Fluctuation of the random process should be limited within possibilities of the total power units, and the distribution is close to normal. In mathematical modelling of wind farms, unlike conventional stations, should take into account a correlation between the capacities of individual wind farms in different regions. Territory location of wind farms is limited by administrative boundaries or geographical area, and the correlation of wind conditions depends on the averaging time range. Wind farms which geographically close and have a strong correlation can be considered as a single object, and weakly correlated – as independent. Thus, the all the wind farms can be divided into some clusters that can simplify the numerical analysis of their impact on the grid. Their short-term power variations are practically independent, while the average daily values are fairly high correlated. The main assumption of modelling is that wind farms power is represented by the season trend curve, the average daily value as random variable and the current short-term changes as a random process of Ornstein–Uhlenbeck type. As the comparison with actual data for several months, the model based on daily interaction of wind farms is quite adequate, and the models excluding inter-daily component usually overestimates the need for additional reserves. It is possible to simulate the wind speed, listing then in power, either directly power of wind farm. Given the properties of the random variables at different time ranges can significantly improve the results of the comparison of actual and simulated values. This allows you to more accurately assess the impact of wind farms located in different regions.

**Donets A.** (Kyiv).

#### **Analyzing the existing types of wind-diesel systems.**

The article discusses the use of wind-diesel systems with appropriate climatic conditions due to rapid rise in prices for diesel fuel, including transportation costs to remote areas. The author suggests two basic methods for system operation with continuous or intermittent operation of diesel engine, as well as their advantages and disadvantages. The article shows the main components of wind-diesel system and their description. To describe the wind-diesel systems there has been used quaternary classification adapted system of Mann and MakGouana and each component types in accordance with their advantages and disadvantages has been discussed in details. The article also discusses basic block diagrams of wind-diesel systems and provides their analysis.

**Moroz A.** (Kyiv).

**Method to analytically determine hydropower potential range for a small river based on linearization probability distribution of water consumption.**

As the title implies the article describes the method of analytical determination hydropower potential range of a small river on the basis of linearization probability distribution water consumption. Are defined and substantiated basic limitations and suppositions to use the water flow during operation of small hydropower plants. It is dealt with formulas for the calculations the power and energy of water flow for small hydropower plants with different number of units subject to the limitations on the use of river runoff in low flow and flooding. It is carried out calculations research determining of hydropower potential of small rivers at different levels of security for example hydrological characteristics of the river Striy. The results obtained demonstrate that the change in power generation stations do not change in proportion to the installed capacity for all values availability of river flow. Is recommended to apply as an indicator of small hydropower potential of the river achievable amount of electricity generation, but installed capacity - only as an additional reference index.

**Pukhovy I., Postolenko A., Radchuk Yu.** (Kyiv).

**Analysis of heat supply circuits with two heat pumps, using ventilation and air emissions, heated by water produced by crystallization.**

Using ventilation air in a heat pump is an effective means to increase the transformation coefficient. But there is a lack of ventilation air for all heat supply needs, especially in the coldest frosty season. The exhaust ventilation air can be cooled in the heat pump but it doesn't provide heat supply. Moreover it requires additional use of a heat pump by means of heat derived from water crystallization to heat up the air to minus 3 - 3°C during low temperature period both for heating frosty air in the ventilation system and for the heat pump. Due to the high heat index of water crystallization heat consumption is minimal.

There have been developed and analyzed 3 circuits with two heat pumps. The first circuit is functioning under independently connected capacitors and two others functioning by series connection in case when the chilled water enters the heat pump in the open air.

Transformation ratio of the heat pump in the open air during low temperature period is about 2.2. Using the casting mold prior to the heat pump can increase transformation ratio by 13-20%.

There should be used warm floor for heating purposes. As for reducing temperature in place prior to first heat pump capacitor the heating and ventilation systems should be turned on in series along the coolant. There has been defined necessary power amount of cold ventilation source for public and residential buildings depending on the multiplicity of ventilation. For efficiency schemes without crystallization water heat the ventilation frequency rate for residential buildings should be 4.5 (it is actually 1) and it should be 3 for public buildings. In-series connection of heating system and ventilation in parallel to in-series heat pump capacitors connection reduces the temperature of the coolant standing prior to condenser working in the open air and also increases its transformation ratio.

Thermal insulation of buildings contributes to relative ventilation share and schemes efficiency with obligatory use of crystallization water heat in ventilation and a heat pump simultaneously. The schemes and their description have been presented. The calculation results have been presented in graphs and tables.

**Zhovmir M.** (Kyiv).

**Analysis of conditions for burning of volatiles and air mixtures at biomass combustion.**

Submicron particles emission at biomass combustion is associated with improper burning processes, especially those of volatile substances. Improvement of volatiles burning out and preventing their carrying out from furnace is a priority approach to achieve environmentally safe biomass combustion [1, 2].

At combustion of particulate biomass in layer on the moving grate actually, owing to biomass thermolysis, there is separate burning of two fuels derived from it – the volatile substances and the coke residue. In previous works temperature conditions, occurring at volatiles and coke residue burning, and concentrations of combustible components and oxygen, that are formed in volatiles and air mixture, were analyzed [3, 4].

In this paper it is shown that volatiles and air mixtures can be divided into seven zones, with typical values of the air to fuel ratio, the oxygen and combustible components concentrations depending on the biomass moisture content and the air to fuel ratio. It is presented the analysis of possibilities for forced ignition of mixtures (from sparks or open sources of flame), thermal self-ignition in volume, thermal decomposition of volatiles, carrying out of unburned volatiles from furnace. Design and operational mode measures for proper ignition and burning of volatile substances were substantiated and unwanted burning modes were identified.

At biomass moisture content  $W_r < 23\%$  volatiles and air mixtures are capable to forced ignition in a wide range of air to fuel ratio: from the sub-stoichiometric values to the modest air surplus.

At biomass moisture content  $W_r < 36\%$  volatiles and air mixtures are capable to forced ignition at air to fuel ratio  $\alpha_{v,i}=0.8$ , and after ignition the secondary air can be added to ensure operational total air excess.

At biomass moisture content  $W_r > 36\%$  volatiles and air mixtures are not capable to forced ignition and their reaction can occur according to mechanism of thermal self-ignition in volume.

At biomass moisture content  $36\% < W_r < 45\%$  to ensure volatiles and air mixtures thermal self-ignition in volume it is expedient creating of adiabatic condition due to refractory lining of furnace.

At biomass moisture content  $45\% < W_r < 55\%$  to ensure volatiles and air mixtures thermal self-ignition in volume it is expedient creating of adiabatic condition due to refractory lining of furnace and adiabatic temperature rising due to hot air blowing.

**Golub N.B.** (Kyiv).

**Bio-hydrogen (bio-methane) production from microalgae wastes.**

Technological scheme of biotechnological biomass recycling of microalgae, cultural medium and biodiesel production waste in gaseous energy (biogas and hydrogen) includes: stages of growing sowing material for the destruction of organic material and hydrogen production; double-stage an-

aerobic fermentation of liquid and solid waste; energy sources purification. By creating the right conditions on the fermentation stage, implements the formation of microorganisms associations - destructors of raw materials and producers of hydrogen. The process separation in 2 stages can increase the rate of conversion of organic raw materials and energy formation. Using low pH values in the first ferment the death of methane synthesizing microorganisms- consumers of hydrogen will occur, this increases the output of hydrogen. It is shown that to prevent changes in the metabolism of microorganism's concentration of organic material in the ferment should not exceed  $60 \text{ g/dm}^3$ . The rational solution ratio of raw materials to bioenergy glycerol fraction (15: 1), glycerol

fraction is formed during the biodiesel production. Addition of glycerol fraction can increase yield of hydrogen and hydrogen concentration in biogas by 10%. Purification of hydrogen from  $\text{CO}_2$  is performed by using a concentrated solution of  $\text{NaOH}$ . The formed soda is used to neutralize the solution before hydrogen or methane synthesis stage. The remains of the culture medium after separation of microalgae biomass is transported to the second ferment. Excess sludge is a high quality fertilizer.

The proposed technology allows intensification of the process; also reduce its duration and energy consumption twice than normal. Water is used in closed loop. The concentration of hydrogen and methane in biogas is increased by 10%. Hydrogen, which is obtained with this technology, has a purity of 97-99%.

## ХІІІ МІЖНАРОДНА СПЕЦІАЛІЗОВАНА ВИСТАВКА ЕНЕРГЕТИКА В ПРОМИСЛОВОСТІ-2015

ЕЛЕКТРОТЕХНІЧНЕ, СВІЛОТЕХНІЧНЕ ОБЛАДНАННЯ, КАБЕЛІ, ПРОВІДИ, ЛІНІЇ  
ЕЛЕКТРОПЕРЕДАЧ, АВТОМАТИЗАЦІЯ, КІПІА, ЕЛЕКТРООБЛАДНАННЯ УСТАНОВОК, МАШИН,  
ЕНЕРГЕТИЧНЕ ОБЛАДНАННЯ

ХІІІ МІЖНАРОДНИЙ ФОРУМ  
ПАЛИВНО-ЕНЕРГЕТИЧНИЙ КОМПЛЕКС УКРАЇНИ:  
СЬОГОДЕННЯ ТА МАЙБУТНЄ



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