**Complex Problems of Power Systems Based on Renewable Energy**

**Bekirov E., Karkach D., Abibulaev A., Voskresenskaya S., Asanov M. (Simferopol). Reducing environmental risks caused by atmospheric pollution when using renewable energy sources.**

Possibilities to optimize energy supply of Balaklava resort city are considered with the use of renewable energy sources – heat and power solar systems workings in parallel with boiler rooms. The solar radiation over solar collectors comes from the surface water pool of an exhaust quarry. The main task is to ensure that the mode of operation and heat load distribution takes into account the factors of environmental risk during the boiler rooms operation. The distribution of heat loads between the energy sources of boiler rooms and solar collectors of an exhaust quarry water basin has been considered. The calculation of the possibility of using the exhaust quarry water basin as a heat accumulator for heating in the winter has been made. The dynamics of temperature change in the accumulator during five years is analyzed. Use of renewable energy sources provides environmental safety and reduces the risk of diseases by reducing harmful emissions during boiler rooms operation.

**Dobrovolskyi V., Yershova O., Solonin Yu. (Kyiv). Investigating the impact of obtaining $MgH_2$and its exposing in the open air on its thermal stability and hydrogen desorption kinetics.**

Safe storage of hydrogen is still today one of the main problems for its use as an energy carrier. Moreover, the choice of the most suitable storage methodology becomes crucial when hydrogen is produced starting from renewable and intermittent energies, as wind or solar energy. It is considered that the most prospective and encouraging materials providing for such requirements are metal hydrides based on magnesium and its alloys. Scientists all over the world have made a lot of studies regarding development of new hydrogen-accumulating magnesium-based materials. However, practical use of these materials is restricted by the problem, which has not been solved so far. This problem concerns two well-known significant disadvantages of magnesium hydride and Mg-based alloys, namely their slow kinetics of hydriding-dehydriding and high dissociation temperature.

The influence exposure to air and of mechanical dispersion upon hydrogen-sorption properties and thermal stability of hydride phase $MgH_2$ synthesized by two different methods - through direct hydriding in gaseous medium (HGM) and by reactive mechanical alloying (RMA), has been studied employing thermodesorption spectroscopy and X-ray photoelectron spectroscopy (this method was employed in the present work to study chemical states of powder surfaces of the composites). The dependence of the temperature of the beginning of hydrogen desorption from hydride phase $MgH_2$ of composites (synthesized by different methods) upon the exposure to air after the synthesis has been established. The exposure of this samples to air for 10 days causes the temperature of the beginning of hydrogen desorption of the $MgH_2$ phase to increase: by $100^0$C in the $MgH_2$ phase (HGM) and by 65 and $12^0$C in $MgH_2$ (RMA, 10 h) and $MgH_2$ (RMA, 20 h), respectively. It has been established that the mechanism of influence of surface upon thermal steadiness and kinetics of hydrogen desorption-resorption from hydride phase $MgH_2$ as follows: the smaller degree of poisoning surface particles during their exposure to air the smaller increase of temperature of the beginning of hydrogen desorption as well as temperature of hydride decomposition during its heating in ambient conditions ($P_{H2}$ = 0,1 MPa) can be expected. XPS-spectra of $MgH_2$ hydrides (HGM and RMA) indicate that oxides formed on surfaces of different $MgH_2$ are similar to each other with respect t to degree of ionicity of the Me-O bonds, however they reveal different abilities to involve and keep on their surface catalytically harmful impurities.

**Kuznietsov M. (Kyiv). The influence of renewable sources semiconductor converters on network power quality parameters.**

In the paper the features of solar and wind power plants semiconductor converters are given and factors affecting network power quality parameters are analyzed that allow evaluating better renewable plants impact on the grid.

The main differences of solar and wind power converters are the structure and operating point selection algorithm. In wind power plants powerful up to 3 MW frequency converters with DC link based on multi-level schemes are used, while for solar plants inverters with power up to 500...650 kW based on bridge circuits are typical. The complexity of the operating point selection algorithm (maximum power point) for wind power converters is in cumbersome calculation of instantaneous power curve for wind generators real operation conditions and for solar power converters – in of the global peak determining among local under their dynamic changes.

Analyzed factors are divided into deterministic and chaotic. Deterministic include factors related to: 1) the switching key elements influence; 2) the reference signal reproduction; 3) the input signal distortion transfer to the output. These factors are described by total harmonic distortion *THD* and cosine of the angle between voltage and current $cos\varphi$, the analysis of their impact on the network for single converters under normal conditions shows that the power quality parameters remain within regulatory requirements acceptable limits. Chaotic factors are related

to: 1) the use of maximum power point search algorithms; 2) semiconductor converters tendency to chaotic processes and 3) converters large number compatible control. The chaotic factors influence is difficult to estimate especially with renewable plants operation in real grid. This is caused by the reduction of traditional power plants control potential of the power quality parameters with solar and wind plants power increasing. The evaluation of renewable and traditional power plants mutual influence as well as the methods of synchronization of their operation requires further research.

Renewable sources semiconductor converters operation doesn't cause the distortion of generated power quality parameters more than limits set by requirements of corresponding regulatory standards under constant primary sources generation and power grid parameters. However, the combined operation of a large number of converters in real grid and under climatic influences creates a potential hazard of significant power quality parameters distortion.

**Solar Energy**

**Ryeztsov V., Surzhik T., Shchokina V. (Kyiv). Possible reasons for the formation of inhomogeneous structures when drying moisture containing mediums by solar energy.**

Solar drying moisture contains phytogenies bioenergetics resources in particular timber? Is one of the most promising technological uses of solar energy. Needed be noted that the evaporation of moisture have necessary technological operations for the preparation of vegetable bioenergetics resources for their use in energetic devices, connected with use of thermal energy, which appears in the burning process.

In practice, even with the natural interaction of solar radiation with moisture contain mediums different origin in their volume (or surface) are formed different inhomogeneous structure.

Because, in fact the same situation may occur when the purposeful use of solar radiation in the processes solar drying then becomes relevant questions about the reasons and mechanisms of the appearance of such inhomogeneous structures.

In the article shows that, in consequence of the availability of differential operators unpaired (first) order in the equations which describe the heat energy transport processes in the cylindrical and spherical coordinate systems, in the dispersion equation for the disturbing frequency may appear a complex coefficients. This leads to the fact that the roots of the dispersion equation may also be complex, which causes the vibration behavior of the changes perturbation in temperature over the time.

It is established that the value of the perturbation frequency component can be depend on the coordinates, which in turn can serve as a qualitative explanation of the causes of inhomogeneous in the volume formation of inhomogeneous structures that appear in the actual conditions in the solar drying moisture contain mediums.

Analyzing the structure of the basic equations can be also concluded that the outlined methodology and results on the complexity $\omega$ can be generalized to the case when convection $\left(\vec{V} \neq 0\right)$ is taken into account, since in this case the operator $\nabla\left(\delta T\right)$ has odd derivatives in all directions.

**Pukhovyi I., Khandus' M., Khrulenko O. (Kyiv). "Wall Trombe-Michel" solar heating system with an extended buffer zone and transparent ceiling in the house with no traditional heating system implemented.**

There have been conducted field tests of a passive solar system "wall Trombe- Michel" in the house in Kyiv suburbs. The system has got an extended buffer zone between the wall and stained glass (RSTM) and a transparent roof in the buffer zone. The distance from the glass to the wall – 1,2 m. Such system allows facilitated maintenance after stained glass transparency (dust cleaning) as well as using the buffer zone for different household needs (greenhouse, place for the rest etc.). The system is built close to the south-western wall of the building with previously made holes for RSTM thus providing air circulation between buffer zone and the room in this house on the ground floor. The outer brick wall room in the south-west part has got 5 holes: three in the top and two in the bottom, where latches are provided for closing at night during cold season and the room from overheating in summer. Fewer holes are made in the bottom due to higher density of cold air. There were made studies of the temperature conditions in spring and the ability to provide heating the rooms in autumn. In sunny October days the research room with RSTM does not need traditional heating. The buffer zone top temperature in spring is 35°C and the floor temperature is 58°C. The wall provides short-term energy storage. The circulation of warm air through the upper hole continues for several hours after the walls exposure is terminated. Air velocity measurement (up to 0,8-1,6 to m/s) in the wall holes allowed finding the mass air flow and the amount of heat entering to heat up the adjacent room. Average efficiency index of the system in May is about 0,5.

**T. Surzhik, F. Gamarko, S. Matyakh, V. Shchokina (Kyiv). Features of Poynting's theorem application for the analysis of electrothermal condition of photo batteries and solar collectors.**

It is well known that the photo and helio energetic temperature condition of the active surfaces of photo batteries and solar collectors is vital both for the influence of temperature factor on the efficiency converting energy solar radiation into electricity or thermal energy, and the reliability and resource of functioning photo battery and solar collectors. For example, an increase temperature of the active surfaces of photo batteries leads to reducing the energy conversion coefficients of solar radiation into electrical energy in solar cells. Increased temperature of the surface solar collectors leads to reduction energy coefficients of solar radiation into thermal energy, which is especially important in the using concentrators of solar radiation. In both cases, the important the space temperature distribution, which is determined by the distribution of density heat release, and which depends on thermal stresses and integral values of heat release.

On the basis of the use the system of Maxwell's equations for the selected frequency of solar radiation in terms of real and complex variables substantiated represent density ohmic heat release in the absorption of solar radiation through the divergence of the Poynting's vector.

When using divergence theorem on vector integral operations for the transition from the differential equation of heat conduction in partial derivatives for the temperature to normal differential equation relative to averaged volume temperature with integral sources heat release. It enables to analyze the thermal state of photo batteries and solar collectors within the parameters of the capacity and the systems of accumulation of electrical and thermal energy.

## Wind Energy

**Kuznetsov M. (Kyiv). Guaranteed levels of wind farms participation to cover grid power.**

The issue of scheduling of grid which contains wind farms, planning its work, the calculation of reserve capacity require some guaranteed indicators (with certain probability), despite the random nature of wind speed and wind farms appropriate power. It is necessary to assess the economic efficiency of wind energy compared to traditional. One measure of guaranteed wind farms participation is the so-called capacity credit of wind, or the equivalent traditional power plants, which replaces the wind farm without loss of reliability of power supply. This approach provides a single value of extra power, it looks as wind farms provides for a uniform probability additive to load duration curve, although in practice this supplement is asymmetrical about the maximum and minimum guaranteed level. Guaranteed minimum and maximum levels of wind power are defined just asymmetrical. The most common approach to the calculation of these indicators is the mathematical modeling; statistical information and analytical representation are also used. In modeling the wind farm's current capacity is considered as the sum of mean value for the long period (trend line), mean value for the day as a random variable and the current short-term changes as a random process of Ornstein-Uhlenbeck type. A single wind farm has no guaranteed minimum and maximum capacity, it may change from zero to nominal value inclusive. Zero values (when the wind speed is lower than the start) and nominal (maximal when the wind speed is higher estimated) cover 10-20 percents of the time, depending on the season and region. Instead, for a total capacity of several wind farms some non-zero probability appears for boundary achievable values. Compatible power distribution of grid and wind farms has even more smoothed character, because their facilities have nonsynchronous changes. When wind farms have dispersed location in areas with sufficient wind potential so their contribution to the overall power of the system can be guaranteed in a fairly narrow range within 95% of the time. Guaranteed supplement capacity in winter will be about 30% of the rated capacity of wind farms, and the maximum will not exceed 50%; summer respectively 15% and 30%. For small size of wind farm its output is virtually the aerodynamic coefficient, further utilization rate falls, thereby devaluing the increase in the nominal capacity. This is especially noticeable in the case of wind farms, concentrated in a limited area that can be considered as unit station. Simulation model and analytical study of the wind speed distribution lead to the similar conclusions. So, guaranteed participation of wind energy to ensure power grid is quite predictable.

## Hydroenergy

**Ibragimova M. (Kyiv). Weighted average coefficients of variation and skewness of annual streamflows for small rivers of Ukraine defined on behalf of small scale hydropower tasks.**

Sustainable use of natural resources, including water resources, is one of the key issues for nowadays development. Theoretical and practical hydropower questions related to the tasks of determining water use potential in municipal and power sectors are solved by hydrologic principles.

Hydrologic processes in nature are governed by the laws of chance and can be quantified by a probability distribution. The probability theory methods in hydrology provide an opportunity to investigate mutual effect of local *streamflow formation* factors. The latest ones are typical for small river basins.

One of the main hydrological characteristics is a discharge (the volume rate of water flow). So an *average discharge rate is considered as random variable, which is characterized by the chosen* probability distribution. The Krytskyy-Menkel three-parameter probability distribution

of water flow is most prevalent probability distribution in the CIS countries. Parameters of this streamflow distribution are the coefficient of variation, skewness coefficient and discharge.

The large territory of Ukraine and impossibility of direct streamflow measurements by hydrometric methods causes the paucity or even lack of hydrometeorological data at the investigated water balance station. Due to this, the spatial averaging of probability distribution parameters based on the existing hydrometeorological information has been used. The averages have been made for territories defined in accordance to the hydrographic river basin type scheme. The estimates have been obtained in order to reflect streamflow exceedance probability and environmental restrictions on use of water when determining small hydropower resources and energy performance indicators of small hydropower plant.

The weighted average evaluation of the skewness coefficient and coefficient of variation has been done by the water content of defined territories.

**Geothermal Energy**

**Khvorov M. (Kyiv). Forming the quantitative characteristics of geothermal waters in complex use.**

Geothermal water is primarily considered as a promising alternative energy options. Comprehensive study of the physicochemical properties of geothermal water indicates that it includes a significant amount of dissolved gases (mainly methane CH4 in the amount of 1-3 $m^3/m^3$) and of chemical components (I, B, Br, Cs, Li, Sr), extraction which contributes to a more rational use of geothermal resources. However, each of the sources operated or planned to use is different from the other in their chemical composition and physical properties that must be considered to determine both opportunities and feasibility of implementation of the production of a chemical element or their combination. Establishing such a process is carried out only after a thorough preliminary study of the chemical composition and other parameters of the actual geothermal water as such, as well as operating system specific sources of geothermal energy to obtain data on the possible extent of daily, seasonal and annual volume of production of certain chemical components.

A systematic storage of such information in a computerized database created specifically carried out as an important step in determining the source of status and natural features geothermal sources and the changes that occur in it during its operation to take account of these facts when designing various systems using geothermal resources. T he structure is designed base assumptions regarding the study and use of mineral chemicals geothermal water consists of five blocks of information, the first four of which are filled according to the general content, and the fifth – a special analytical information for direct practical use.

**Kravchenko I. (Kyiv). Mathematical model of planned-radial filtration of the geothermal fluid as part of its flow continuity equation.**

Ukraine meets its energy consumption needs nearly 45–47%. Due to difficult geological and technological conditions the cost of fossil fuels in Ukraine is often higher comparatively to other countries where it has to export them from. The most important task the Ukrainian fuel and energy complex faces is enhancing and maximizing the use of its own energy sources for thermal and electrical energy generation including the development of renewables. One of renewables is the heat from deep subsurface. To master and develop this renewable energy potential there should be used the heat of already explored thermal water reserves. This resource hasn't been sufficiently studied in Ukraine even in terms of forecasting. It should be emphasized that forecasted operating life presupposes the amount of natural heat source that could be removed by thermal water intake within the selected area at a given maximum allowable reducing required level and during the operation lifetime and equipment.

Estimation of these resources on a national level is made by appropriate specialized geophysical and geological organizations and enterprises by using approved procedures and instructions.

When exploring geothermal reserves the interested consumers use their own corporate research studies of local nature by using existing hydro geological information and mathematical processing tools. These tools are presented by mathematical models working formulae thus allowing feasibility and rationality evaluation of investing in this power sector with sufficient probability.

This paper has analyzed and grouped into a single consistent algorithmic chain some mathematical postulates towards obtaining the mathematical model and working formulae in order to estimate hydro geological parameters and energy capacity of geothermal fields.

**Barylo A. (Kyiv). Evaluating options to use depleted gas fields in geothermal energy.**

The analysis of the gas deposits development in Ukraine was executed. The analysis shows there is the sufficient resource base to use mine-out gas deposits for the energy supply. Most elaborated deposits are in the Western oil and gas region (more than 50% from the total amount). In the Eastern region there are about 25% of mine-out gas deposits, besides several horizons developed by 80%. Least of all the Southern region has been elaborated.

The database of elaborated gas deposits in Ukraine was compiled. The database includes 46 deposits with an average degree of development 70% and higher. It is

shown that energy potential of elaborated deposits directly depends on the type of flooding. There are two types of water flooding: a uniform and non-uniform. During the first type of flooding all gas reserves are retrieved from the reservoir, stratal waters with the background values of gas content are filling the productive horizon. At the second type of flooding the penetration of underwater into a gas bed takes place thus preventing natural gas extraction. As a result there are remaining reserves of gas in productive horizon. The article shows basic estimation principles of energy potential deposit for both types of flooding.

The geothermal potential of Medenetsky gas field has been determined. This field belongs to the first type of flooding. The total production of thermal and electric energy due to the use of geothermal waters with gas from Medenetsky field consists of 4515 MWh per year. It will allow reducing organic fuel consumption about 708 t.o.e.

The total production of thermal and electric energy due to geothermal waters utilization as well as Chernukhensky field remaining gas reserves (second type of flooding) is about 50 000 MWh per year which is 12 380 t.o.e.

**Bioenergy**

**Kovalko A., Novosetsev O., Evtukhova T. (Kyiv). Energy-economic estimation of scenarios of transboundary cooperation between energy service companies on the rapeseed and biodiesel markets.**

Energy-economic aspects of realization of the different scenarios of energy service companies' cross-border cooperation in the rapeseed and biodiesel markets are considered, new possibilities for using the energy-technological systems, interacting subsystems of which are located in different cross-border areas (countries) are showed in the paper. It is allows to identify new opportunities for the implementation of energy-saving innovative projects to improve competitiveness of energy technologies, expanding the boundaries and increasing the extent of attracting investments in the renewable energy sector.

The involvement of Energy Service Companies (ESCOs) is fundamental for the implementation of the proposed approach, since they, by their main goal, focused on providing the customer interaction on energy saving innovation projects with strategic investors, suppliers of fuel and energy resources, and manufacturers of innovative energy-efficient equipment, including those, located in different countries and/or in different economic zones (areas) of one country.

From the point of view of rapeseed and biodiesel energy-efficiency technologies, first of all, the determination of such factors as productivity (yield and oil content in seeds of rape, etc.), the cost and loss of energy, logistical and human resources and prices and tariffs on input energy resources and the main product (biodiesel) and by-products of biodiesel production (straw, rapeseed meal, glycerin) were done.

In addition to technological parameters for the proposed approach were considered energy efficient and basic economic parameters, such as, for example, dynamics of changes in purchase prices for rapeseed in the US, Germany and Ukraine.

Despite the fact that attracting investment in conventional biodiesel projects in developing countries without cross-border cooperation) for all 12 considered scenarios had shown their unprofitability, the implementation of cross-border cooperation mechanisms in the field of energy saving innovation projects allows to obtain a positive total income from interaction of ESCOs, located in different countries, and thereby expand the borders and enforce the scale to attract investments in such projects.

**Kovbasenko S.V., Simonenko V.V. (Kyiv). The road test bus, running on traditional fuel and biodiesel.**

With the gradual depletion of oil fields, which causes a significant increase in the prices of traditional fuels for engines of road vehicles, the question arises about use of alternative fuels from renewable resources.

One of the alternatives to traditional petroleum fuels is biodiesel plant origin, such as rapeseed oil methyl esters.

For validation of the mathematical model, which was developed by the National transport University and characterizes the motion of the bus with diesel engine in the modes of urban driving cycle were conducted road tests bus PAZ-32054 with diesel engine 4CH11,0/12,5 (D-241) in accordance with the requirements of GOST 20306-90. According to the rules of the road tests were identified indicators and characteristics of fuel efficiency, such as fuel consumption when driving in the modes of urban driving cycle and fuel characteristics of the steady motion of the bus.

After the road test bus that runs on traditional fuels and biodiesel have been processed research results.

Road test results show an increase to 12% mass flow of biodiesel compared to traditional petroleum fuel when driving in bus mode urban driving cycle and in determining fuel characteristics steady motion. The fuel consumption in thermal equivalent virtually unchanged.

The adequacy of the mathematical model of the motion of the bus with diesel engine in the modes of urban driving cycle performed by comparison of the results of mathematical calculations with experimental results. The discrepancy between the results is less than 5%, which confirms the adequacy of the mathematical model.