Complex Problems of Power Systems Based on Renewable Energy

Zaporozhets Yu. (Kyiv). Sustainable Development Strategy: ways of overcoming the global contradiction "energy-economy-environ-ment" and scenarios for Ukraine.

"The future we want" – outcome document of the UN Conference, known as Rio + 20", approved by General Assembly resolution 66/288 of 27 July 2012, and a number of other documents previously developed by the world conferences under the auspices of the UN, compiled the official version of modern civilization paradigm – "The Strategy of sustainable development".

The Strategy has recognized as one of the most serious problems of modern times the threatening growth of greenhouse gas emissions, primarily carbon dioxide, as a result of excessive burning of worldwide fossil carbonaceous fuels. The Strategy aims at achievement of the balanced integration of all three components of sustainable development – economic growth, social development and guard of environmental by strengthening of international adjusting of conservancy.

The article from the standpoint of estimations, requirements and objectives that define the global Strategy of sustainable development, systematically analyzed the role of the main negative factors of anthropogenic impact on the environment and climate of the planet. In the article there is revealed indissoluble link of contradictory problems in modern industrial society development at the field of energy, economics and environment ("3E") and the validity of Rio Strategy challenge: the transition to sustainable development in the world requires radical changes of consumption and production mode set in the countries.

On this basis, put forward the concept of integrated approach to overcome the global contradiction between the needs of the global community and its individual regions for continual increase of energy capacity and endurance of natural ecosystem to adverse anthropogenic interference in its fundamental processes that are facilitated by ruthless economic mechanisms. In context of this approach the article has identified the most effective technical measures to neutralize and prevent the negative consequences of the imbalance of consumption and production, which was the reason of growing contradictions in the system "3E", designated specific technologies, which can ensure the achievement of Strategy objectives, and executed prognostic assessment of their effectiveness.

So, along with passive measures for energy saving in industrial countries there are expanded in power engineering and industry the implementation of CCS systems (Carbon Capture and Storage), and the replacement of environmentally "dirty" energy-intensive industries by the energy-efficient technologies, using low carbon raw materials. These technologies include the application of steam-gas turbine power plants with the integrated coal gasification cycle and cogeneration.

Significant role in plans to reduce emissions is a program for substitution of traditional fossil fuels by renewable energy resources, among which a special role is assigned to hydrogen. Practical steps and actions for the development of hydrogen energy in the direction of becoming a "hydrogen economy" meet an increasing scientific and financial support. One of the ways of realization of the hydrogen scenario in the Strategy of sustainable development context has become the technology of "Power to gas" (P2G) – a mixture of natural gas and hydrogen, produced by the energy of irregular renewable sources (wind, sun, waves), and delivered to consumers by means of existing gas infrastructure.

The traditional product of chemical industry - ammonia that is used for large-scale production of fertilizers and other nitrogen compounds is represented in new quality. Replacement of dominant power-hungry technology of synthesis of ammonia by burning of enormous volumes of natural gas on an immediate electrochemical synthesis of ammonia in solid state reactor from the nitrogen and hydrogen, got directly from air and water by means of renewable energy, provides preconditions for using of ammonia as a fuel in a gas-turbine and other engines. Power efficiency of ammonia exceeds even hydrogen, unlike him, does not create problems with storage and transporting however, so it appears very promising as a motor fuel for cars.

The paper shows the profound situation in priority of solutions of contradictory problems in the energy sector and the economy of Ukraine, a hostage of which the ecology actually turns out to be. However, the possible applications of facilities and measures designated to resolve the tasks put by Strategy of sustainable development are exposed in Ukrainian

conditions. Significant potential of renewable energy resources is particularly marked, available in the vast shelf area of Ukraine, which can be mastered by means of marine floating platforms, equipped with wind-sun power plants and hydrogen cycle facility. To build such floating power platforms and provide their acquisition there are completely adapted domestic shipyards and existing industrial enterprises.

Solar Energy

Gaevsky A., Ushkalenko O. (Kyiv). The calculation method worked out on energy balance base of an autonomous PV power plant.

The major problem in autonomous solar plant designing is the sizing of PV system components. In this paper the method of PV plant calculation based on energy balance equations for mean values of daily insolation, energy consumption and cumulative battery energy has been developed. The basic schemes of power flows between PV modules, loading and storage system have been taken into account. The required batteries capacity and the PV modules number are calculated on the base of insolation and loading profiles. This procedure is more accurate than the conventional method of "worst month" or "worst days" which ignores the balance equation for the whole working period. Our method can be applied to any period or autonomous mode of PV plant operation.

Khairnasov S. (Kyiv). State of the art for heat pipes usage in solar thermal and combined collectors.

The existing building stock in most European countries is relatively old. About 70% of buildings are constructed before 1980. The situation in Eastern Europe including Ukraine is even more dramatic and is improving very slowly. For example, the total energy consumption in building sector is about 40 % of Ukraine's energy use while up to 75% of heating energy is consumed by residential buildings. In Ukraine old non-renovated buildings lose major part of space-heating energy. Such buildings consume 4 times as much energy as the new ones. This requires implementing energy efficiency measures in building sector not only in Ukraine but also in other countries. In order to provide the energy efficiency increasing of buildings it is reasonable to apply a wider range of options, considering a building as a complex system of livelihood. Additional use of solar energy could be perspective. Solar energy systems applications for the buildings facades, including historical ones, have good future prospects. A variety of flat plate solar collectors (FPC), evacuated solar collectors (ETC), thermosyphon solar water heaters (TSWH) and photovoltaic-thermal module (PVT) designs have some shortcomings for application to building constructions. FPCs, ETCs, TSWHs and PVTs based on heat pipes (HPs) could be a good solution for building facade and roof integration. HPs can be used as constructional elements of solar collectors and at the same time as elements of building envelopes. The solar collectors based on HPs might be adapted to the facade by means of their various shaping and assembling of the similar light weight modules. Each HP is an autonomous hermetically sealed device which might be connected "in dry" to the main pipeline. They need no service and, if it becomes necessary, can be simply dismounted without recharging the cooling agent which is circulated. It should be noted that the cost of such solar system installation also could be reduced due to the simplicity and flexibility of integration into building facades. Today, the widespread application of FPCs, ETCs, TSWHs and PVTs based on HPs makes significant contribution to the solution of the energy efficiency. The use of HPs as heat transfer devices and heat exchanging equipments allows creating a efficient solar energy equipments of the new generation. Heat pipes can be widely used in order to improve the outdated equipment: improving its efficiency, reliability and life time, and to create high-quality new technology. To date day there are the following areas where heat pipes are widely used: flat plate solar collectors, evacuated solar collectors, thermosyphon solar water heaters and photovoltaic-thermal module. The article provides an analysis of the current state of heat pipes using in such solar energy systems.

Wind Energy

Kuznetsov M. (Kyiv). Wind energy influence over wind power grid stability.

There is current growing of wind power stations Ukraine. However, the variable nature of the power inherent in wind energy, can lead to a negative impact on the combined power grid. This applies in particular stability of dynamic processes in power systems. Balance of power consumption and fre-

quency control – key technical problems in power systems with a significant level of wind energy. Important characteristics of wind farms is current capacity and its probability distribution, including minimum, maximum and average values needed to identify needs in reserve. Also important is the rate of change of power affecting the stability of the grid.

Modern industrial wind farms are not connected directly to the grid and use non-inertial power electronics (inverters) for partial or complete interface with the system. Consequently, they are not directly involved in electromechanical oscillations. However, increasing the share of wind farms they have an indirect impact on damping properties of the grid. Current regulations in Ukraine provide that in the calculation of system dynamic stability should consider disabling of wind farms if significant deviations voltage or frequency of power network operation. Over time, wind power will to take responsibility in maintaining the frequency of the system in case of wide introduction of wind power.

Simultaneous unpredictable disconnection of many wind turbines can cause unbalance emergency. This threat is achieved by creating a reserve capacity and prediction of the expected wind speed. If there are several operated wind farms separated by many miles, then their combined capacity varies quite smoothly. The impact of wind farms on the static stability are also small, but additional loading (or unloading) of wind generation in some way affect the stability margin.

For wind farms generally accepted definition of dynamic stability is preserved, but instead maintain synchronism fault must meet short-passing mode voltage drop. An international experience shows that a major problem in the power system is not so much the level of wind farms penetration, as the level of power fluctuations. This characteristic must be controlled at a choice of deployment scenarios for wind energy.

Modern wind turbines are actually programmable, and they are quite flexible for rapid control of active and reactive generation capacity within the project boundary. If power fluctuations of wind power can be reduced to a value that does not require a significant increase in demand for spare capacity and creates great frequency disturbance, then the amount of wind power may be perfectly acceptable.

Golovko V., Kokhanevych V., Shykhailov M. (Kyiv). Rotor orientation system analysis of a low capacity wind turbine.

Today rotors with horizontal rotation axis equipped with aerodynamic profile blades are among the most common and effective systems to convert kinetic energy into mechanical air flow. The maximum energy extraction from this type of air flow rotors occurs when the rotor plane is perpendicular to its direction. To fulfill this condition horizontal axis wind turbines should have the systems of rotor orientation in the direction of air flow.

Since the early development of wind power there have been designed many options of rotors orientation. Investigating them is practically impossible and aimless. It is necessary to analyze the data systems based on their reliability, frequency of use, efficiency, etc., and to determine the orientation system priority for further research. In addition it should be noted that nowadays orientation rotors system in technical literature have been studied mainly in terms of their design features, reliability, speed and precision targeting, etc. Thus there are no available studies as for defining assessment criteria for losses of electricity or other energy losses depending on the choice of orientation system.

The analysis of rotors system orientation shows that the most applicable systems are those when rotor orientation is performed without removing the rotor of the wind through rotor sails or tail vane plane and wind rotor withdrawal by using constructive scheme ‘the tail on oblique hinge’.

It has been established that orientation system without departing from the rotor direction of air flow and determining the energy loss in the process of work there should used wind flow parameters and angular orientation of the rotor speed in the direction of wind flow, depending on the angle of deflection of the rotor and wind speed. For a system of orientation deviation of the rotor the energy losses are determined by its static characteristic.

Perminov Yu., Kokhanevych V., Budyonnyi I, Donets A. (Kyiv). The algorithm for calculating synchronous generators excited by permanent magnets for wind turbines.

In modern small capacity WPPs synchronous generators excited by permanent magnets are mostly

used for electricity generation. Various generators designs determine specific nature for elements calculation. Nowadays due to design experience there should be obtained results and created algorithms to calculate basic synchronous generators designs for further use in wind turbines.

The paper suggests an algorithm to calculate the cylindrical generator with a radial magnetic system and the windings located in the stator slots. The generator is made of electrical steel sheet and has been tested on 200 Watts generator.

The algorithm consists of the following stages:

- Step 1. Select rated parameters of the generator;
- Step 2. Calculate generator parameters;
- Step 3. Calculate magnetization characteristics;
- Step 4. Specify electrical parameters of the generator;
- Step 5. Calculate 200 Watts generator and provide its experimental verification.

The deviation of the experimental data on the results of the calculation algorithms for power generator 200 does not exceed 8%.

Hydroenergy

Pazych S. (Kyiv). Technical parameters' evaluation of a marine hydropower storage plant for renewable energy utilization.

According to the Directive 2009/28 / EC the renewable energy should cover 20% of the total electricity consumption by each country by 2020. Decision of the Council of Ministers of the Energy Community D / 2012/04 / MC-EnC agreed that Ukraine should have 11% of renewable energy in total energy consumption by the end of 2020.

Enforcement of the above conditions requires improving the power quality of wind and solar power caused by the stochastic process flow of primary energy, which negatively affects the entire machine to convert and transfer this energy to the end user.

One of the ideas to solve this problem is to use a compatible renewable power and pumped storage hydroelectricity (PSH) designed to smooth the ripple generating capacity. Using the PSH on seawater provides additional opportunities for wide introduction of renewable energy sources in the coastal zone. Create PSH promotes:

- Direct accumulation of excess wind or solar energy;
- The use of energy storage to equalize load demand of the consumer;
- The use of stored energy to cover uneven schedule of wind and solar power;
- High quality "green" electricity from renewable power sources.

Pumped storage in seawater has several embodiments:

1. Using the traditional difference in elevation between the coast and the sea surface.
2. The establishment of marine PSH using underground storage tanks (mines, catacombs, etc.) as the downstream.
3. Creation of marine PSH directly into the sea or near the coast, where the sea is the upstream and reservoir dug in the sea – the downstream.

Some of the options are implemented and some are just the projects.

For our country only 1 and 3 embodiments fit marine PSH. The report further considered options for selected marine PSH in terms of technical capabilities and physical parameters based on world analogues construction of hydraulic structures.

Geothermal Energy

Kudelya P., Dubovskyy S., Tverdokhlib O. (Kyiv). Thermodynamic characteristics of heat transformation process in heat pumps driven by heat.

Using besides compressor heat pumps (HP) heat transformers operating in heat pump mode is currently one of the most effective measures to save fuel and protect the environment. To understand transformation of heat in HP with thermal drive and evaluate energy transformations it is necessary to conduct a detailed analysis based largely on concepts like exergy and energy (exergy analysis) which is reduced to application of exergy, entropy and energy balances. Using other types of analysis, such as energy analysis, violates the principles of systematic approach and makes it impossible to obtain correct analysis results.

The paper proposes a systematic approach to analyzing thermal using heat pumps which is based on the requirements of the second law of thermodynamics (exergy approach). It gives a possibility to understand the peculiarities of heat transformation in such an HP and to assess their thermodynamic perfection most

simply and clearly. Dependences are established to determine such performance efficiency indexes as coefficient of exergyefficiency η_{ex} and coefficient of thermo-dynamic efficiency η_{TE}. Irreversible heat impact on η_{ex} and on coefficient of operating power COP and also relationship and differences between indexes such as η_{ex}, η_{TE}, were investigated in detail and illustrated using graphs.

Bioenergy

Klyus V. (Kyiv). Autothermal technology for bird droppings carbonation.

Disposal of bird droppings at poultry farms is rarely used because of the high cost of natural gas used for its drying. As a result of the accumulation of large waste amounts the environmental situation on the nearby territories is extremely difficult.

We have developed the technology of autothermal carbonization of bird droppings in dense layer reactor. For the start carbonation initial ignition process is needed, and then the process is carried out auto thermally by the combustion of volatile substances released during heating droppings. To convert the droppings into the fuel droppings were mixed with fine grounded biomass (sawdust, peat, straw chaff). A mixture of droppings and biomass was granulated and dried in a natural way 5 to 7 days, or in the dryer to moisture content up to 40%.

Experimental verification allowed setting the parameters of the process, among which the most important are: the temperature (550-820°C) and air density of the blast. The yield of carbonized residue for chicken droppings was 53-57% and for quail droppings – 32-38%.

The advantage of the technology is its energy efficiency, cost, environmental safety and disposability.

The carbonized droppings hold increased concentration of nutrients, and fixed carbon is converted into activated carbon, having sorbing properties.

Golub N., Leleko I., Kozlovets O. (Kyiv). Impact of raw material co-fermentation over biogas yield.

The paper shows possibility of biogas obtaining from hemp waste and its processing products such as paper in mesophilic anaerobic process. The influence of poultry manure content, as additional substrate, on biogas yield and its methane contents was analyzed. It is shown that rational hemp/manure rates is 85:15 at dry ashless mass. With such ratio biogas yield increases 2 times compared to pure hemp, methane contents in biogas – 70%.Increasing or decreasing of poultry manure component causes biogas yield and methane content in it to rapidly decrease, this is due to influence of ammonia nitrogen contents, nutrients, vitamins and growth factors.

It is defined to accelerate methanogenesis and facilitate microorganism's access to cellulose fibers the preliminary treatment of raw materials is required. The expediency of 1 hour steam treatment, due to low lignin contents in raw materials. Pretreatment with acid causes acidification of medium, which negatively affects methanogenesis.

Ions of ferrum have positive influence on microorganism's development. Addition of extra amount of ferrum (II), 100 mg/dm^3, increases the biogas yield up to 2 times for raw materials pretreated with acid and decreases yield by 23% for raw materials pretreated with steam. In case the no-pretreated paper is used as substrate adding ferrum (II) ions causes methane yield to grow 40%. The resulting dependence can be explained with the influence of hydrogen ions concentration. Upon acidification of medium the permeability of plasma for ferrum ions decreases but the influence of ions on cellular processes grows, due to better solubility of compounds. On the neutral pH of medium, that is observed when pretreatment with steam is used, ferrum partially combines with phosphate ions, then adsorbs on the surface of particles and as such becomes less available for microorganism's cells. Also the ferrum excess can influence the contents of other nutrient elements in cell, especially phosphor, which decreases the contents of methane; this is true for raw materials pretreated with steam.

When paper made from hemp is used as a medium the contents of methane in biogas is 51%.