Complex Problems of Power Systems Based on Renewable Energy

Burkova E., Burkov D. (Sevastopol). Environmental assessment of safety level for heat supply systems in municipal facilities (on the example of Balaklava district).

One of the major problems of modern society development is to ensure environmental safety. Special attention is paid to the environmental safety of zones for recreation and tourism. This article is devoted to the problem of environmental pollution in Balaklava district of Sevastopol city.

The main sources of pollution in Balaklava district are automobile transport, mining activities and heating plants. Heating plants produce the second largest emissions of CO after automobile transport.

As a rule the existing methods of assessment of heating plant impact on the environment are based only on direct damage to the ecology of the area which houses the heating plants. But taking into account the development of alternative energy sources it is required to pay attention to the following damage assessment criteria: saved fuel, water for heating plant maintenance, saved oxygen and others.

In general the value of the prevented ecological and economic damage can be presented as a sum of various prevented damage types: reduction of fuel consumption (natural resources); pollutant emissions into atmosphere; fresh water consumption; wastewater discharge; salt intake; slag formed when coal is replaced by solar energy; and reduction of oxygen consumption. Further articles will discuss approaches of assessment of these components.

The proposed method of the prevented ecological and economic damage assessment allows forecasting damages to the environment during design of a heating plant, and it also allows assessing the effectiveness of applicable environmental protection measures including the creation of the heating plants based on alternative energy sources.

Solar Energy

Bondarenko D. (Kyiv). Using solar panels for autonomous environmental monitoring systems.

Using of low power solar PV-battery for supply of distributed electronic systems is good idea. PV-battery with power of 10W is reasonably to supply many control-measurement devices or communication devices.

For monitoring ecological situation we can use different devices like CO2-monitor, CO-monitor, VOC-monitor. For communication we can use low power digital equipment.

Because, these are low voltage devices with low power, supplying of these devices can do by solar PV-battery.

On the basis of the above, there was collected a pilot plant. It comprised:

1. Solar PV-battery with power 10 W and voltage 12 V;
2. Lead-acid battery voltage of 12 V and a capacity of 4 Ah;
3. The charge controller that generates two voltages 5V and 12 V;
4. Monitor of carbon dioxide, which consists of an infrared detector, controller and relay module, and measures the concentration of 0 to 5000 ppm;
5. Communication device, which is based on GSM / GPRS-module SIM9000.

For monitoring by three devices, we should use more power PV-battery and more capacity accumulator. For example PV-battery power is 70 W and accumulator capacity is 30 A·hour.

Also, we can do smart controller for supplying different devices at different time and considering solar activity.

Ushkalenko O. (Kyiv). Online resource for PV power plant sizing.

One of the topical problems in photovoltaics is a PV power plants sizing (PV field size, batteries capacity) with the economically feasible equipment. Selection of such equipment depends on both PV power plant location, mode of operation and sizing method. Now the most widely used method is the one based on the worst operation conditions and leads to the PV power plant oversizing.

In the current article you can find information about new online resource launch. The main purpose of this resource is to make users familiar with new PV power plants sizing method, which based on the produced and consumed energy balance. This method takes into account availability of the accumulator batteries and amount of energy stored in them for every PV plant's operation day.

In order to launch calculation on the site user should provide monthly data about insolation for PV plant location and monthly data about load. PV sizing can be done with or without limiting of the total accumulator batteries capacity.

The results of calculation are PV power plant's solar field size and total capacity of the accumulator batteries.

Wind Energy

Kuznetsov M. (Kyiv). The impact of wind power on the energy system static stability.

Large-scale integration of wind farms to the electricity grid raises a set of problems. Grid can absorb certain part of wind power without significant difficulties, but in excess of this value it may be difficult to ensure the stability of electricity generation. The stability of the energy system is determined by the perturbations that caused uncontrollable nature of wind. Verification of static stability of power systems is performed by calculations of the aperiodic and vibrational stabilities. It is shown that the impact of wind farms on vibrational stability of the grid can be considered insignificant due to the lack of periodic disturbance at critical frequencies. A significant factor is sudden emergency power imbalance due to rapid change in wind farm capacity. Especially dangerous is the sudden shutdown of wind farm. Analysis of wind regime shows its probability is very low, only possible emergency shutdown in violation of frequency or voltage that is independent of the wind farms themselves. The subject of the study is uncontrolled power fluctuations in wind power due to the sudden change in wind speed. Additional loading or unloading of a controlled intersection because of wind generation can reduce the stability, and in excess of the maximum active power value the transition to post-accident treatment begins. To assess the impact of wind farms on power system stability checked how their current output conforms to the regulations disturbances. It is shown that the impact of uncontrolled change power increases with decreasing local grid. In normal mode, the average power can be considered as well predictable and random component is within certain limits. If the random component does not exceed the calculated limit, the value of disturbances in the power system allows the transition to post-accident regulatory regime. Since the random variables studied, the performance of the stable conditions should be determined as probability that meets the requirements of reliability. It is shown that the designed capacity of wind farms in Ukraine does not exceed the limits of sustainability for the entire grid. If we consider the local-controlled intersections, the effect of wind farms on the stability determined by the ratio of wind and traditional power stations by section. So, for limited areas we should take into account local conditions. It is recommended equally as possible to place wind farms and avoid their high concentration in a limited area. It should also continuously to predict the wind speed and coordinate wind farms operation with the network operators.

Golovko V., Kokhanevych V., Shykhailov M., Marchenko N. (Kyiv). The effect of rotor orientation system parameters with a spring-loaded tail constructive scheme over static characteristics of the wind turbine.

The development of small wind power requires constant WTs improvement as a whole and its individual components, including rotor systems orientation. In the process of designing a targeting system the developer faces the task to select those options that will ensure minimal energy loss.

The authors offer to consider the rotor orientation system with weathercock and using constructive spring-loaded tail. There has been suggested a mathematical model of the orientation system. Based on this model there should be obtained static characteristics and power curves considering design parameters that will further analyze the impact of structural parameters over energy losses.

Based on the mathematical model there were defined parameters determining static characteristic of the regulation system and the power curve. These parameters are as follows:

- Spring stiffness;
- The value of preloading springs;
- The value of rotor axis displacement in relation to rotation head axis;
- Tail angle setting relatively to airflow.

The analysis results gained from static characteristics and power curves lead to the following conclusions:

- the system can distinguish an orientation parameter group, whose influence on the static characteristics power and curves leads to changes in the initial velocity adjustment (increase or decrease) in value and maximum power according to their shift towards an increase (or decrease) of the wind speed. This is the initial tension and regulation spring stiffness and the distance from tail rotation axis to the springs attachment point to tail;
- impact of tail angle setting relatively to airflow can be considered negligible;
- displacement of rotor axis relatively to the axis of head rotation should be taken more than 0.2 meters for wind turbines with a rotor diameter 6 meters aiming to reduce displacement impact of the centre of front pressure over the rotor.

Kayan V., Lebed A. (Kyiv). Darrieus wind turbine with direct controllable blades: experience creation, testing, performance optimization.

Wind power is one of the most promising and fastest growing sectors in the global power industry. Many countries are working to develop new and more powerful wind turbines and to expand the territory and operating wind ranges in the wind industry.

All commercially available wind turbines are divided into two types: with horizontal axis (HAWT) and vertical axis (VAWT) of rotation. Each type has its advantages and disadvantages. The VAWT advantages (in comparison with HAWT) are included a smaller earth part at the same power and a substantial simplification of power unit design due to the placement of the power equipment in power unit base, rather than the external power housing for HAWT. Disadvantages of VAWT are the high speed of self-starting and large vibration on turbine shaft. The studies of some type of VAWT carried out to improve the advantages and reduce the disadvantages of these turbines.

It is known that controlling the blades position of Darrieus type VAWT can substantially improve its performance: reduce the rate of self-starting, decrease loading on the turbine shaft, increase the overall energy efficiency. Controlling is carried out by turning the blades on crosspieces so that angle of attack of blades for each point of the trajectory of rotation will be optimal. The authors have been produced and experimentally researched several models of wind turbine with different mechanisms of control: without control (fixing blades) for comparison, with an shifted ring, which is attached to blades controlling axis (control mechanism №1), and with the special shape of control track, which provides predetermined angle of attack of the blades in each point of its circular trajectory (control mechanism №2).

The results are given in the form of graphs. Tests of VAWT have shown that the using of the control mechanism №1 reduces the rate of self-starting, speed of turbine rotation decreases at the same received power, loading on the turbine shaft decreases and the overall coefficient of turbine energy Cp raises in a certain range of tip speed ratio λ. Using of the control mechanism №2 showed similar effects to a greater extent. This mechanism is much more versatile and allows more optimally control of the blades position, but it is more difficult to implement technically.

For the calculation of control track shape a computer model of flow around wind turbine has developed and extensive numerical studies of various flow parameters were conducted. Tests of VAWT IGM-3 with controlling track, which calculated by results of computer modelling, has shown good coincidence to results of calculations and the greatest increase of turbine energy coefficient Cp = 0.45 among all researched VAWT models.

Sandoval Z. (Kyiv). Wind energy flow analysis in Ecuador Republic.

The article analyses wind power flows in Ecuador. The obtained data will be used to assess the possibility of installing autonomous WPP mainly in rural areas.

Due to National development program of Ecuador in 2009-2013 the country got electrified covering 98% urban and 96% rural households. However regional Amazon provinces still suffer shortages of electricity. Average household electricity consumption is 1,402 kW·h and this figure is going to increase over time. Such trend encourages the involvement solar and wind energy, as well as other renewables to replace conventional fuels and improving country's energy balance. Today the share of renewables in total energy balance of the country doesn't exceed 2% (excluding hydropower).

To assess the feasibility of installing autonomous wind turbines for households in remote rural areas of

Ecuador the most important is getting sure about available sufficient wind power there. In general the geographical position of Ecuador makes it the country with low wind speeds. However some exceptions are made in mountainous areas where the wind power projects are proposed to be conducted. To find potential sites for WPP the Atlas wind potential has been used. The Atlas is a part of ARTPOWER software and Google-Maps software tools.

The greatest potential of wind energy flow is for sure in mountainous areas. According to calculations the average wind speed in mountainous terrain is from 4.3 m/s to 7.3 m/s at 20 meters altitude and the power density of the wind flow – from 33.4 W/m^2 to 167.6 W/m^2. Using Google Earth-AWS Truepower packet program the potential area for wind turbines siting was estimated. According to the results the most effective sites for wind turbines are located in provinces Carchi, Imvavura, Pichincha, Cotopaxi, Azuai.

Hydroenergy

Vasko P., Vasko V., Ibragimova M. (Kyiv). Small hydropower as a part of electricity sector in Ukraine.

Integrated Power System of Ukraine is the backbone of the country's Electric Power Industry. It is a complex of power stations, electric and thermal networks, which are combined by a common mode of electricity and thermal energy production, transmission and distribution according to its centralized control.

In 2014 the total installed capacity of power plants in Ukraine was 55.11 GW. Most of the installed capacity comes from thermal power plants (34.3 GW), one quarter – from nuclear power plants (13.83 GW). The rest comes from hydroelectric power stations and pumped-storage hydroelectric power plants with the capacity of 5.85 GW and renewable energies – 1.13 MW.

Total electricity production in 2014 was 182.4 billion kWh/year. The main producers are nuclear (48.5%) and thermal (45.7%) power stations. Hydropower industry and renewable energy produced only 5% and 0.8% of the electrical energy respectively.

The total hydropower potential of Ukraine is over 44 billion kWh (including 3.0 billion kWh of small hydropower). Today the cost-effective potential is about 17.5 billion kWh, and it is already used about 11 billion kWh (60%). Thus, the untapped potential is about 6.5 billion kWh.

Hydroelectric power plants cover peak loads; control frequency and power; provide mobile emergency reserve of power in Integrated Power System of Ukraine.

At the beginning of 2015 Ukraine has 105 small hydropower plants with total capacity of about 82 MW and average annual electricity production of 250 million kWh/year. Most stations were put into operation in Vinnitsa region, where the total capacity is 22.45 MW. Kirovograd, Ternopil and Transcarpathian are the regions with the highest level of installed capacity.

According to "Energy Strategy of Ukraine for the Period until 2030" the potential of small hydropower is estimated at 1140 MW with annual electricity production of 3,34 billion kWh/year.

In Ukraine, the valid State Incentives for small hydroelectric power generation are: – privatization of small hydro power plants; – "green" tariff; – tax benefits; – preferential access to the electric network.

According to existing legislation small hydropower plant has to be privately owned or leased (large hydropower stations are not subject to privatization).

"Green" tariff is applied for almost all renewable energy sources (except for electricity produced by large hydroelectric plants). It is set for each entity by the National Commission for State Energy and Public Utilities Regulation. The tariff takes into account construction costs, maintenance of power plants and rate of return for electricity producer.

The scheme of stimulating the production of electricity through "green" tariff is set until January 1, 2030. The size of "green" tariff coefficient for electricity generated by power plants, which will be commissioned or significantly upgraded after 2014, 2020 and 2024, is reduced by 10%, 20% and 30% respectively. The state guarantees the purchase of electricity and its full payment.

In Ukraine, there are a lot of national laws and programs for protection, conservation and wise use of natural resources, as well as international treaties, conventions and protocols.

The current regulatory framework of the country provides good opportunities for the development of small hydropower.

Pazych S. (Kyiv). Analysis of structural analogs of marine pumped storage HPP.

The idea of using water resources as the battery in the power is quite innovative. The driving force of water has long served the needs of mankind in various fields, but the realization of moving water from one place to another is the first step in the development of modern hydro pumped storage With growing electricity demand and the development of the electricity sector, through the construction and development of renewable energy, there is a need improving the quality of power transmission from renewable sources to final consumers use pumped storage station for accumulation of energy wind power and solar power is an effective way of integrating the electric power system, which in turn makes it possible to accumulate and sell renewable energy in large quantities cost-efficient and cost-effective pumped storage station provides more than 150m elevation, and such conditions are rare. That is why some countries have recently put forward proposals for alternative ways of constructing PSPs in their coastal areas using seawater.

The closest analogue marine pumped storage station is a tidal power that is widely used around the world, located on the shores of seas and oceans. Based on the circuit design of tidal stations offers a variety of technical options for the use of sea water resources

Geothermal Energy

Barylo A., Khimenko O., Vasylchenko M. (Kyiv). Studying hydrodynamic and thermal characteristics of wastewater drainage facilities at the M.M. Gryshko National Botanical Garden.

The aim of this paper is to define the waste water parameters from the drainage and antilandslide system of the M. M. Gryshko National Botanical Garden. At present this water discharge into Dnipro River. We propose to use waste water for irrigation of the greenhouses and the domed orangery. Experimental testing of the temperature and the flow rate of wastewater are carried out. Annual alterations of production rate do not exceed 20%.The technological scheme of the rational waste water using is proposed. It would improve environmental conditions of the territory and reduce the amount of purchased water. Using of waste water to be improve of environmental conditions Land Botanical Garden reduce the amount of water discharged on the slopes p. Dnieper thereby reduce landslides effects.

Lysak O., Kulinko Ye. (Kyiv). Prospects of using surface water for heat pump heating systems.

The article deals with the prospects for implementation in Ukraine of surface water heat pumps. The analysis of the implementation problems is made to assess these prospects.

First of all, the terminology used for describing surface water heat pumps is reviewed.

Another part of the analysis is the consideration of the possibility to use surface water as a heat source for heat pumps. The water temperatures define this possibility. At the place where water is used the minimum water temperature should be above the water freezing temperature. Depending on the water parameters the minimum water temperature should be above the water freezing temperature at least from one to several degrees Celsius.

It is also shown how much heat could be gained from surface water (if the chosen surface water can be used as a heat source). The amount of heat that can be gained depends on the water properties (density, heat capacity, and salinity), the minimum water temperature and the volume of water resource that can be used by heat pumps. The minimum water temperature defines a maximum water temperature drop caused by heat pump heating systems. Values of temperature drop should not be high because that can lead to negative consequences for aquatic life. The determination of the volume of water resource that can be used by heat pumps is quite difficult and varies for different types of water sources.

These theoretical guidelines are compared with data from actual projects in Ukraine and abroad. It is noted that the design surface water temperatures are higher in recent projects compared with earlier ones.

Also, we considered two types of surface water heat pumps: open-loop and closed loop. The advantages and disadvantages of both types are shown.

One of the parts of this work is the comparison of COPs (coefficient of performance) for air source heat pumps and surface water heat pumps. Air temperatures are taken in the range of outdoor design temperatures for heating systems in most Ukrainian regions. Water temperatures are taken in the lowest

range that could be used for heat pump heating systems. For these ranges the calculations show that surface water heat pumps have higher COPs than air source heat pumps.

In conclusion, we see that there is a need for research and development of surface water heat potential in Ukraine including the creation of the surface water heat map.

Bioenergy

Klius S. (Kyiv). Experimental study of processes for biomass energy technology converting in fixed bed reactors.

The article presents the results of experimental studies energy technology conversion processes the main types of solid biomass into combustible gas and biochar in fixed bed reactors.

The processes of biomass gasification in inverted downdraft gasifier have been studied. Objective of research is to establish the basic processes in solid biomass gasifier, producing combustive gas and biochar in conditions that meet really possible technological regimes of thermal conversion.

Experimental set up have been created. It consists of an insulated vertical shaft type reactor, air blower, hot gas condenser and measuring units, for air flow and reactor temperatures monitoring. Later it was improved with high-temperature gas filter.

According to the previous studies, consistency of initial combustion and forming of gasification zone is essential. Ignition by the torch of flame gave as various results and was not acceptable because of high smoke concentration in laboratory. Starting with red-hot heated charcoal had the best results. Thus gasification zone was formed right after the blower was turned on.

Acceptable parameters of fuel feedstock were chosen for different fuels. For the size of reactor we took particles of the matching size, previously calculated. Moisture content of biofuels for traditional gasification processes should be as low as possible, at least twice as low as it is for freshly cut down wood. As for studied process freshly cut down ivy and birch with moisture content Wr=47.5% and Wr=45.0% respectively was good enough and process run smoothly with good output biochar production.

An opportunity of gasification heterogeneous low bulk density fuels was identifying. The results of the experiments showed that the heterogeneous low bulk density biofuels gasification is unstable because of the high porosity and forming areas with different hydraulic resistance. To align hydraulic resistance specified fuel is recommended to grind fractions 3 ... 5 mm or granulated.

In this work the boundary of air blast quantity for chosen fuels was defined. We had best results for air blast quantity between 27.5 up to 179 $m^3/(m^2 \cdot h)$. Technological parameters such as specific fuel reactor performance, velocity of the gasification zone moving, temperatures in gasification zone by air blast quantity was shown at figures 4-6. The height of gasification zone front movement was calculated. For studied fuels it was nearly 4.5 sizes of fuel particles.

Experimental studies in processing wood, energy crops and plant waste into fuel gas and biochar, made it possible to obtain new data on the parameters of the conversion of biomass. Thus, for the first time determined the possibility of gasification of wood with a moisture content up to 47.5% in the dense layer gasifier and expanded the range of air blast quantity (27.5 ... 179 $m^3 / (m^2 \cdot h)$), within which there stable process of biomass gasification. Studied for specific fuel performance of the reactor fuel was 36.5 ... 133.6 kg / ($m^2 \cdot h$), and the speed of the gasification zone – 9.2 ... 50.5 cm/h. It is planned next phase of research to determine the quantity and quality of the release of flammable gas, biochar and directions for their use.