Project name: IRN AP14872147 «Development of an efficient power supply system for autonomous consumers based on a special design wind farm».

Relevance: In the context of increasing energy consumption, it is important to reduce costs in the power supply system. This is relevant for autonomous consumers, who are usually low-power, and in agriculture, electricity consumption can also be seasonal, which leads to high costs.

The use of renewable energy will reduce the cost of energy consumed by replacing organic fuels. The climatic and natural conditions of the Republic of Kazakhstan provide ample opportunities for the use of wind energy.

The solution to this problem is possible by improving the wind turbine using a special design. The principle of rotation of the anchor and inductor parts of the generator from separate counter-rotating wind wheels is proposed.

Purpose: The purpose of the project is to develop an efficient power supply system for autonomous consumers based on a special design wind farm with increased electric energy production.

Expected results for 2022.

To carry out a comparative analysis of various power supply schemes for autonomous consumers of electric energy. To analyze the existing power supply systems based on traditionally used energy resources. To analyze the state and development of renewable energy-based power supply systems. To analyze the state and development of power supply systems based on wind turbines.

During the implementation period, young specialists, including two PhD doctoral students, were involved in the scientific project.

In the course of the research conducted in 2022, the following main results were achieved.

The experience and conditions of using renewable energy in the power supply system are systematically analyzed and the structures of the power supply system using a wind turbine are presented.

The study of domestic and foreign scientific, technical, patent and licensing information in the field of research was carried out. 129 sources of information were analyzed. During the research, much attention was paid to various power supply schemes for autonomous consumers of electric energy. The great demand for small wind power plants for agricultural facilities has been revealed, which creates prerequisites for the research and development of energy-efficient wind power systems for autonomous power supply.

The experience and conditions of using traditional energy sources in the autonomous power supply system are systematized. The analysis showed that the existing power supply schemes of industrial enterprises meet the necessary requirements for power supply. The electricity supply to agricultural consumers and settlements in rural areas looks somewhat different due to its peculiarity, the presence of a large number of low-power and dispersed consumers of electric energy over a large territory. The transmission of electric energy through rural electric networks, due to their length, requires high costs for their operation. At the same time, 75% of the cost of electricity is accounted for by its transmission.

Agriculture needs to be developed in order to maintain food security. An important factor in the development is the energy supply of consumers, primarily the provision of high-quality electric energy.

The experience and conditions of using renewable energy for autonomous power supply are systematized.

The analysis of literary sources and the experience of using renewable energy sources (RES) abroad and in the Republic of Kazakhstan is carried out.

The analysis showed that the development of renewable energy is observed in all countries of the world, including the Republic of Kazakhstan. At the same time, Government policy is important to maintain mechanisms for the development of renewable energy sources.

The dynamics of the introduction of new capacities based on renewable energy over the past decade shows a steady increase in new capacities and the installed capacity is almost doubling. At the same time, the largest increase is observed in wind and solar energy.

The experience and conditions of using wind energy for autonomous power supply are systematized.

When analyzing the literature sources, it was revealed that the main indicator for evaluating the effectiveness of wind energy is effective structures for a territory with low wind flow velocity. About 50% of the territory of Kazakhstan has an average annual wind speed of 4-5 m/s, and a number of districts have a wind speed of 6 m/s or more, which determines very good prospects for the development of low-power wind energy.

In existing wind power plants (wind turbines), the wind wheels begin to rotate at a wind speed of 3-4 m/s and enter the nominal mode at a speed of 9-11 m/s. Therefore, the development of low- and medium-power wind turbines operating in areas with low wind speeds is an urgent task.

Under these conditions, the development of low-power wind turbines of special design, generating electric energy at low wind speed, will increase the efficiency of wind use. Such wind turbines are in demand for power supply to low-power agricultural consumers, and are more relevant for remote ones where autonomous power sources are required.

According to the results of the conducted research, according to the calendar plan, 1 (one) scientific article was published in the journal recommended by the CQAFSHE MSHE RK and 2 (two) applications for patents or utility models were filed:

1. S.S. Isenov, A.B. Kaidar, B.K. Shapkenov, S.K. Sheryazov Research of a wind turbine in an autonomous power supply system. // Bulletin of Toraighyrov University, Pavlodar. Energy Series, No. 3. 2022. pp. 80-97. ISSN 2710-3420. The scientific journal is recommended by CQAFSHE MSHE RK. http://vestnik-energy.tou.edu.kz/storage/journals/165.pdf.

2. An application has been filed for 1 (one) patent or utility model of the Republic of Kazakhstan. The application was assigned registration number No.2022/0738.1 dated 11.21.2022.

3. An application has been filed for 1 (one) patent of the Eurasian Patent Organization. The incoming number of the national office is 2022-53506. The registration number of the application in the national office 2022/066 dated 11.22.2022

Expected results for 2023.

During the study, the following will be determined: the main design and operating parameters of a wind turbine of a special design with counter-rotating wind wheels and the process of electric generation based on the principle of counter rotation of the armature and the generator inductor. Models of the interaction of wind flow with wind wheels will be developed; the main parameters of a wind turbine of a special design will be investigated; the electric generation mode will be modeled with the establishment of the relationship of the studied parameters. Laboratory models will be developed: wind turbines of a special design based on two-wind wheels and a rotating inductor and an anchor of the generator and its operability will be investigated; electric generators and wind turbines as a whole. The following will be developed: a pilot design sample of a wind turbine of a special design; a wind-mechanical part of a pilot design sample of a wind turbine; an electric generator and, in general, a pilot design sample of a wind turbine.

During the implementation period, young specialists, including two PhD doctoral students, were involved in the scientific project.

In the course of the research conducted in 2023, the following main results were achieved.

In the course of the study, the main design and operating parameters of a wind turbine of a special design were determined and their interrelation was established based on modeling the mode of electricity generation. The process of electric generation is modeled on the principle of counter rotation. The parameters of the wind flow and the wind wheel as a result of their interaction are investigated. At the same time, the wind energy characteristics of the wind flow are determined to simulate the interaction of the wind flow with the wind wheel. During the simulation, it is proposed to determine the average wind speed, which provides the average power for the calculation period, which differs from the average wind speed, and the relationship of the wind speeds under consideration is established. Its power and the amount of expected output, the wind speed at which the rated power is expected and the expected area or diameter of the wind wheel are considered as the main parameters. For maximum output, the working wind speed of the wind wheel was investigated. During the study of the specific expected output from the operating speed of the wind wheel, it was established that there is a wind speed at which maximum electric power generation is expected. In the course of the study, the main design and operating parameters of a wind turbine of a special design were determined and, based on the principle of counter rotation of the armature and the inductor of the generator, their relationship was established based on modeling the mode of electricity generation.

The parameters of the wind flow and the wind wheel as a result of their interaction are investigated. The wind wheel is characterized by a minimum V0, nominal (operating) Vp and maximum Vm wind speed. The wind wheel, at wind speeds below the minimum and above the maximum, does not rotate or is removed from the wind and, accordingly, there is no generation of electric energy. In conditions where the wind speed is above the minimum and below the maximum, the power on the shaft of the wind wheel depends on the cube of the wind speed. At the same time, the wind wheel rotates at a nominal speed at a wind speed equal to the operating speed and higher, up to the maximum. In these conditions, it is important to simulate the operating wind speeds for the wind wheel. To simulate the interaction of the wind flow with the wind wheel, the wind energy characteristics of the wind flow are determined. At the same time, during the study, it was important to determine the wind speed when the maximum flow of wind energy is expected, which can be taken as the operating wind speed for a wind wheel. Since the power and energy of the wind flow depends on the cube of the wind speed, it is impossible to use the value of the average wind speed. In the course of the study, the main design and operating parameters of a wind turbine of a special design were determined and, based on the principle of counter rotation of the armature and the inductor of the generator, their relationship was established based on modeling the mode of electricity generation. Based on the conducted research, a model of interaction between wind flow and wind wheels has been developed.

The main parameters of a wind turbine of a special design are investigated. Its power and the amount of expected output, the wind speed at which the rated power is expected and the swept area or diameter of the wind wheel are considered as the main parameters. In order to obtain maximum output from a wind turbine of a special design, the working wind speed of the wind wheel was investigated. At the same time, it is proposed to simulate the process of expected production from the specific area of the wind wheel. During the study of the specific expected output from the operating speed of the wind wheel, it was established that there is a wind speed at which maximum electric power generation is expected. At the same time, this wind speed Vm differs from the wind speed, which provides average power. So, in an area where Vav.m = 10.9 m/s, Vm.v is equal to 14 m/s, and at Vav.m = 6 m/s - Vm.v = 8.5 m/s. During the study of the parameters of the wind turbine, a relationship was established between the considered wind speeds Vm.v = 1.8 + 1.14 Vav.m or Vm.v = 3.4 + 1.25 Vav. During the research, the aerodynamic characteristics of the wind wheel were determined with the determination of the main parameters and indicators, such as the speed of the wind wheel, the developed torque, etc.

In the course of the conducted research, the electric generation mode was modeled on the principle of counter rotation of the armature and the inductor of the generator. The study established the influence of wind flow on the operation of wind wheels and their relationship. To study the relationship between the design and operating parameters of a wind turbine, a simulation of the mode of electric energy generation was performed. A joint study of the rotation parameters of the

wind wheels with the output data of the generator and the establishment of the necessary dependencies for determining the electricity generated by the proposed wind turbine was carried out. In the course of modeling the process of receiving wind flow energy, it is proposed to determine the average wind speed, which provides the average power for the calculated period Vsr.m, which differs from the average wind speed Vav. Thus, it was found that at an average wind flow velocity of 4.2 m/s, Vav.m = 6 m/s and at Vav = 8.6 m/s - Vav.m = 10.9 m/s. During the simulation, the relationship of the considered wind speeds Vav.m = 1.4 + 1.1 Vav was established. The conducted studies show the establishment of the relationship between the parameters of the wind wheel and the generator with the output parameters of the power generation mode. The electric generation mode is modeled with the establishment of the relationship of the studied parameters. The interaction process of the wind flow of a wind wheel and an electric generator is modeled.

The scientific and methodological and scientific and technical literature on the research topic is analyzed and the features of wind turbines of special design based on two-wind wheels and rotating inductor and generator anchor are highlighted. The technical requirements for the development of a laboratory model of a wind turbine of a special design have been studied. The main design solutions for wind turbines of a special design of this type have been identified. The technical requirements for the development of drawing documentation for a wind turbine of a special design based on two wind wheels and a rotating inductor and an anchor generator are defined. A laboratory model of a wind turbine of a special design based on two wind wheels and a rotating inductor and generator armature has been developed.

When creating a pilot design sample of a wind turbine of a special design, the following main stages of development were carried out. Development of technical requirements for the development of drawing documentation. Production of a prototype device. Testing the device. Revision of the drawing documentation based on the test results. Creation of a pilot design sample of a wind turbine of a special design.

According to the results of the conducted research, according to the calendar plan: 2 (two) articles were published in a peer-reviewed scientific publication with a CiteScore percentile in the Scopus database of at least 35 (thirty-five); 3 (three) scientific articles were published in a journal recommended by the CQAFSHE MSHE RK; 2 (two) applications for patents or utility models were filed Republic of Kazakhstan; 2 (two) patent applications of the Eurasian Patent Organization have been filed.

Foreign publications:

1. Koshumbaev, M., Issenov, S., Iskakov, R., Bulatbayeva, Y. (2023). Development of a vortex wind device. Eastern- European Journal of Enterprise Technologies, 1 (8 (121)), 22–29. doi: https://doi.org/10.15587/1729-4061.2023.274199. (SCOPUS per.47).

https://journals.uran.ua/eejet/article/view/274199.

2. Nurmaganbetova, G., Issenov, S., Kaverin, V., Issenov, Zh. (2023). Development of a virtual hardware temperature observer for frequency-controlled asynchronous electric motors. Eastern-European Journal of Enterprise Technologies, 3(1 (123), 68–75. https://doi.org/10.15587/1729-4061.2023.280357. (SCOPUS per.47). https://journals.uran.ua/eejet/article/view/280357.

Domestic publications:

3. Isenov S.S., Kaidar A.B., Iskakov R.M., Shapkenov B.K., Sheryazov S.K. Classification and analysis of wind power plants. // Bulletin of the Toraighyrov University. Pavlodar. Energy series. No. 4. 2022. pp. 111-129. ISSN 2710-3420. The scientific journal is recommended by the CQAFSHE MSHE RK. https://doi.org/10.48081/XJFT7363

4. Isenov S.S., Sheryazov S.K. Analysis of the state and development of power supply systems based on renewable sources. // Bulletin of Toraighyrov University, Pavlodar. Energy Series, No. 2. 2023. pp. 140-152. ISSN 2710-3420. The scientific journal is recommended by the CQAFSHE MSHE RK.

https://doi.org/10.48081/BEXD7601

5. Koshumbaev M.B., Khatsevsky K.V., Isenov S.S., Nurmaganbetova G.S., Iskakov R.M. Development of a wind device of special design for remote agricultural facilities. // Proceedings of the University No. 3 (92), Section 5: "Automation. Energy. ICT". Karaganda, 2023. pp. 489-495.

DOI 10.52209/1609-1825_2023_3_489.

Filing applications for a patent and (or) a utility model of the Republic of Kazakhstan:

6. An application has been submitted for an examination to obtain 1 (one) patent of the Republic of Kazakhstan «Wind turbine with variable rotation torque of a wind wheel». The application was assigned registration number No.2023/0313.1 dated 05.05.2023.

7. An application has been submitted for an examination to obtain 1 (one) patent of the Republic of Kazakhstan «Wind Power plant». The application was assigned registration number No.2023/0407.1 dated 06.09.2023.

Filing of patent applications of the Eurasian Patent Organization:

8. An application has been filed for 1 (one) patent of the Eurasian Patent Organization «Wind turbine with variable torque of the wind wheel». The Eurasian application was assigned registration number 202391983 in the EAPO dated 08.08.2023. 9. An application for 1 (one) patent of the Eurasian Patent Organization «Wind Power Plant» was filed. The application was assigned the number KZ2023/054 dated 07.24.2023.

Information for potential users: To disseminate the results of the work among potential users, the community of scientists and the general public, the

results of the project will be reported at scientific conferences, seminars, forums, and published in domestic and foreign publications.

Additional information: A high social and economic effect will be achieved.