Project name: IRN AR14871978 "Highly efficient wind generator using a multi-rotor system".

Relevance: There is great interest in wind generation in Kazakhstan, but it is mainly focused on large-scale wind farms. Currently, it is necessary to investigate the list of knowledge required for the integration of micro wind turbines in buildings. By generating electricity locally, wind turbines avoid transmission losses and the cost of a separate connection to the local distribution network. They also provide a visual representation and emphasize a commitment to sustainable energy by promoting a "green" image.

The design of a wind generator with the use of a multi-rotor system is proposed, as well as the development of the design of wind flow amplifier boards. The proposed experimental setup will be developed on the basis of hardware and software for building and prototyping systems, models and experiments in the field of electronics, automation, process automation and robotics.

Objective: to develop a highly efficient wind generator using a multi-rotor system in a built-up environment, where the direction of the wind flow will be modulated to enhance the wind flow of a multi-rotor wind generator with horizontal axes.

Expected and achieved results: Direction of work: obtaining a scientifically based result that solves an important scientific problem of generating electricity using a wind generator using a multi-rotor system in urban and industrial conditions.

Scope of application: urban high-rise buildings and detached industrial enterprises.

The implementation of this project will be the developed concept of a multi-rotor wind generator, which will allow creating such autonomous wind generating substations, where, thanks to technical equipment, wind energy will be used to generate electricity with minimal losses, and for life support of buildings and structures.

According to the results of research confirming its operability, technical documentation will be developed with a list of modern element base for the production of a prototype.

The Ministry of Energy of the Republic of Kazakhstan, akimats of cities and districts, industrial enterprises will be interested in the development and application of the wind generator station.

The forms of implementation of the project result will be:

- at least 3 (three) articles and (or) reviews in peer-reviewed scientific publications indexed in the Science Citation Index Expanded of the Web of Science database and (or) having a CiteScore percentile in the Scopus database of at least 50 (fifty);
- at least 1 (one) article or review in a peer-reviewed foreign or domestic publication recommended by CQASEE;

- development of scientific and technical, design documentation;
- dissemination of the results of the work among potential users, the community of scientists and the general public.

The results obtained:

- A mathematical model has been developed for the digital implementation of the functions of a multi-rotor wind generator device. The main idea was to use the dependence of wind strength on the speed and direction of wind flow. It is based on the power law of velocity distribution. A mathematical model is a logical system for predicting wind characteristics, namely, the application of wind characteristics in an urban environment based on data parameters from a weather station and wind sensors installed near a multi-rotor wind generator.

- The algorithm of the program for translating the functional protection scheme to digital logic using the MATLAB Simulink software package has been developed. The mathematical model has been integrated into a computer model. Wind sensors transmit analog signals to microprocessors, which are converted into a digital signal through an analog–to-digital converter at the input. A detailed algorithm for the operation of the amplification system using an air concentrator of a wind generator has been developed.

- A digital implementation program has been developed for the reversal function of wind flow amplifiers. The software part has the ability to automatically adjust the shield structures of the wind generator, thereby increasing the wind flow in the area of the wind generator location. The servos are installed on 4 sides of the wind turbine and are controlled in a standard way using a software script for turning to the desired angle. The logic of servo control is embedded in a special script written in C++ for the Arduino sketch. Wind speed and direction data are simultaneously transmitted to the web server via the HTTP GET method in the form of string parameters, after which the web server starts processing them in real time. To store incoming readings, a relational database based on the PostgreSQL DBMS was created, consisting of two tables: indications, rotations.

- According to the data obtained, the power generated increases by about a quarter of the model, the research of which was carried out without the use of side panel structures. This, first of all, allows us to say that there is an assertion about the effectiveness of using shield structures to generate electric energy using wind.

The conducted research has shown that the effectiveness of the use of panel structures and the use of a software and hardware complex to control them increases the power of the generated wind energy.

- The design of the wind flow amplifier is justified. According to the results of the study, it was found that the initial data on the characteristics of the wind is greatly distorted during its circulation in the urban environment due to the influence of urban development. In this regard, in the process of modeling the situation, a nonlinear relationship was revealed between the location

of installed wind turbines and a nearby structure, which can change the speed and direction of the wind. Thus, the design of a wind flow amplifier is proposed in the form of stationary devices that are installed on four sides around a wind farm and are intended to increase wind flow and increase the efficiency of a wind turbine.

According to the research results, it was found that the automatic control of the proposed shield structures allows increasing power by 25%.

- An article was published in the Proceedings of the University No. 4 in 2023, in a domestic publication recommended by CQASEE.

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List of publications and patents published within the framework of this project: (with links to them):

1 Zlaugotne B., Zihare L., Balode L., Khabdullin A., Blumberga D., Multi-Criteria Decision Analysis Methods Comparison, //International scientific conference «Environmental and Climate Technologies», 2020, 24(1), p. 454–471. Multi-Criteria Decision Analysis Methods Comparison (sciendo.com)

2 Turgel I., Bozhko L., Ulyanova E., Khabdullin A., Implementation of the Smart City Technology for Environmental Protection Management of Cities: The Experience of Russia and Kazakhstan//International scientific conference «Environmental and Climate Technologies», 2019, 23(2), p. 148–165. Implementation of the Smart City Technology for Environmental Protection Management of Cities: The Experience of Russia and Kazakhstan (sciendo.com)

3 Kasperowicz, R., Pinczyński, M., Khabdullin, A. (2017). Modeling the power of renewable energy sources in the context of classical electricity system transformation. Journal of International Studies, 10(3), 264-272. doi:10.14254/2071-8330.2017/10-3/20. Modeling the power of renewable energy sources in the context of classical electricity system transformation - Journal of International Studies (jois.eu)

4 Khabdullin A, Khabdullina Z, Khabdullina G, et al. Development of a software package for optimizing the power supply system in order to minimize power and load losses International Scientific Conference on Environmental and Climate Technologies (CONECT) 2017; 128: 248-254. Development of a software package for optimizing the power supply system in order to minimize power and load losses - ScienceDirect

5 Tatkeyeva G.G. Power supply of autonomous systems using solar modules, IOP Conference Series: Materials Science and Engineering81(1),012112, 2015, Cite Score:0.6, Percentile: 25. Power supply of autonomous systems using solar modules - IOPscience

Information for potential users:

By generating electricity locally, wind turbines avoid transmission losses and the cost of a separate connection to the local distribution network. They also provide a visual representation and emphasize a commitment to sustainable energy by promoting a "green" image. These qualities have stimulated the growing interest and support for small-scale wind energy technologies from politicians, industry, local authorities and the general public. The technology of creating integrated wind turbines was developed despite the idea that wind speed, as a rule, will be less, turbulence and wind shear will be greater, and the effects of local flow will be more specific than in neighboring comparable rural areas.

The proposal for urban wind power includes all kinds of small wind turbines in an urban or built-up environment, representing a relatively new application for small wind turbines. The relevant technologies are still being developed and are entering the world market.

Additional information:

The significance of the project on a national and international scale lies in the fact that the development of the field of energy conservation was influenced by such factors as additional taxation of the cost of energy resources; political agreements were adopted supporting the idea of rational use of energy;. Improving the “green image of the city”. Also, the rational use and creative application of these installations will attract foreign interest.