ABSTRACT

thesis of the PhD- student Kumyzbayeva S.K. «Intelligent Autonomous systems for combined energy supply based on the trigeneration plant including renewable energy sources» for the nomination of the Doctor of Philosophy (PhD) degree in the specialty 6D071700 – «Heat power engineering»

Relevance. Occupying the ninth place in the world in terms of area, Kazakhstan is one of the last places in terms of population density**.** Complex climatic conditions, a hot dry summer in the south of the country with a temperature of up to 45 ° C and a cold prolonged winter in the northern and eastern regions, where the temperature falls below -50 ° C, impose special requirements on the quality and reliability of heat supply. In general, the situation is exacerbated by the low energy efficiency of obsolete equipment physically and morally. The stability, reliability and energy efficiency of existing energy supply systems in remote and hard-to-reach areas can not be considered satisfactory.

Generation of thermal energy for life support systems and technological needs is carried out practically without alternative by direct combustion of fuel.

Nowdays there are 6936 rural settlements (SPS) in the Republic, where 7.6 million people live, while electricity consumption does not exceed 2.5% of the country's output.

The number of settlements that do not have a centralized power supply, according to official figures, is about 5000. More than 180 thousand households are not connected to electricity networks. As a consequence, there are negative effects of internal migration of the rural population. Losses of agricultural products are great as a result of insufficient power output of production. The lack (instability) of energy supply prevents the introduction of modern technologies in agriculture adversely affects the pace of SME development in the regions. As a consequence, the volume of gross agricultural output barely exceeds 7% of the country's GDP.

Due to the above reasons, the search for energy solutions for remote agricultural facilities, is one of the strategic tasks of Kazakhstan, which is represented in the state programs in the short and long term.

According to the concept of transition of the Republic of Kazakhstan to the "green economy", the share of alternative and renewable energy sources by 3030 should be 30%, and in 2050 - (30-50)% energy sector. This condition requires the development and implementation of environmentally friendly energy-efficient technologies for power supply for various facilities.

Relevance of the work due to the objective state of power supply systems of decentralized facilities of the Republic of Kazakhstan, namely:

– the presence of unacceptably high transport energy losses of low-loaded extended power transmission lines of distribution networks;

– considerable length of highways, gas - and oil pipelines, communication lines, etc., that need to be point sources of reliable and efficient integrated power supply.;

– presence of more than 180 thousand households not connected to electricity networks;

– physical deterioration of network equipment and difficult climatic conditions.

– Kazakhstan's international commitments to improve the environmental situation, reduce greenhouse gas emissions.

The aim of the work is to increase the energy efficiency of autonomous power supply systems by introducing and ensuring optimal operating conditions for trigeneration plants (MTGP)**,** using fossil fuels, along with renewable energy sources (low-grade heat of the earth) in circumstances where the energy load profiles of all types of energy produced have a significant diurnal and seasonal heterogeneity.

In accordance with the goal and taking into account a wide range of research directions, the following tasks:

1. Conduct research and analysis of the application of systems of production of various kinds of energy for the complex supply of various facilities.
2. Develop a dynamic model of the MTGP, which includes individual models: the power characteristics of the internal combustion engine, the electric generator, the compressor of the reversible heat pump, as well as the dynamic model of the energy characteristics of the system of geothermal reservoirs.
3. To develop a comprehensive simulation model of the dynamical system integrated battery power, comprising: a dynamic simulation model Bauman; simulation dynamic model of micro networks of heat, cold and electricity; imitational dynamic model of the consumer of energy.
4. To develop methods for optimizing the structure and composition of ASCES-MTGP.
5. Develop a system for the intelligent management of operating modes ASCES-MTGP.
6. Develop specialized software products for conducting numerical studies of autonomous integrated power supply systems based on the MTGP.
7. Using numerical research methods, a comparative analysis of the effectiveness of MTGP application in comparison with other (traditional) sources for autonomous power supply
8. Based on the results of numerical studies, a comparative analysis of the effectiveness of ASCES-MTGP for the sharply continental climate of Kazakhstan.

The main idea and the internal unity of work. The fundamental idea of the thesis is to study the energy efficiency of autonomous power supply systems based on MTGP. Development of methods necessary for optimization of structure and composition ASCES-MTGP in the context of a sharply continental climate in Kazakhstan. Development of methods for the intelligent control of ASCES-MTGP operation modes for seasonal and daily heterogeneity of energy load profiles. On the basis of the developed methods, the creation of a dynamic simulation model and, specialized software products for modeling and simulating the work of ASCES-MTGP, as well as analyzing the energy, economic and environmental performance of ASCES-MTGP in selected climatic conditions of operation.

Scientific novelty:

1. Developed a dynamic model of the new generation of power generating equipment - monobloc geothermal trigeneration unit (MTGP). Experimental studies on the physical model helded. The proposed model was calibrated.

2. Numerical studies and new knowledge on energy and environmental indicators of ASCES-MTGP in the conditions of different climatic zones of Kazakhstan for loads peculiar to housing and communal services.

3. Developed generalized technical structure of the Autonomous System of Integrated Energy Supply based on MTGP (ASCES-MTGP).

4. Proposed concept and a software product for numerical studies of energy and environmental indicators of ASCES-MTGP. The software is based on a complex dynamic simulation model that includes the specificity of the MTGP generating equipment, dynamic properties of a renewable energy source (geothermal heat exchanger), daily and seasonal profiles of the consumer's energy loads (heat, cold, electricity).

During the study used the classic position of power system, correct assumptions, modern methods of mathematical modeling, a comparison of the results of theoretical numerical studies with the results of physical experiments, which makes it possible to consider the **scientific propositions, conclusions and recommendations of the thesis to be valid and reliable**.

Reliability of work. The obtained results have the necessary degree of reliability, for the following reasons**:**

MTGP energy efficiency studies were carried out on a real test bed, as well as on a pilot system of integrated power supply based on a diesel geothermal trigeneration plant;

- the results of experiments and numerical simulation are consistent with the results of other authors;
- At carrying out of physical experiments high-precision devices and information computing systems;
- The research was carried out by carrying out multiple experiments.

Reliability of work is also confirmed by good convergence of the results of physical experiments and calculations using the created digital models.

The practical value of the work is to develop and create a simulation model of a geothermal trigeneration plant, as well as a software product for:

- calculations of the optimal structure, composition and intelligent control of MTGP operating modes based on daily and annual load profiles for all types of generated energy required for the design of ASCES-MTGP;
- calculation of energy, economic and environmental indicators of ASCES-MTGP.

As a result of the thesis, the effectiveness of the ASCES-MTGP application in the context of sharply continental climate.

The results of the research work were used in two projects financed by grants of the Ministry of Education and Science of the Republic of Kazakhstan.

Provisions for the defense:

- generalized technical structure of ASCES-MTGP;

- methodology for calculating the energy and environmental performance of ASCES-MTGP in terms of the energy load profiles of the consumer (electricity, heat, cold);
- methodology for optimizing the structure and composition of ASCES-MTGP equipment based on the modified Rossander schedule;
- simulation model (MI) of joint generation and accumulation of electricity, heat, cold in ASCES-MTGP.

The personal contribution of the applicant is:

– in the analysis and compilation of literary data;
– in carrying out numerical modeling;
– in the planning, organization and conduct of experimental research, the processing and synthesis of results;
– in the development of new technical solutions.

Approbation of dissertation results. The results of the thesis are approved at five international scientific and practical conferences:

1. The 2016 International Conference on Cogeneration, Small Power Plants and District Energy (ICUE 2016). "Hybrid stand-alone power supply system in conditions of extreme continental climate in Central Asia. Kumyzbayeva S.K., Ibragimova MV., Stoyak V.V., Apsemetov A.A. – Bangkok, 2016.
2. VI International Scientific and Technical Conference "Kazakhstan-Chill 2016". With the report "Complex power supply of autonomous objects on the basis of Trigeneration installations." Stoyak VV, Kumyzbaeva SK, Ibragimova MV, Apsemetov AA - Almaty, 2016.
3. International Scientific Conference "Environmental and Climate Technologies – CONECT 2015". «Combined power supply of decentralized energy consumers in conditions of extreme continental climate». Stoyak V.V., Kumyzbayeva S.K., Apsemetov A.A., Ibragimova I. – Riga, 2015.
4. XII Annual Conference of National Instruments. With the report "Modeling the operation of a hybrid autonomous system based on a monoblock trigeneration plant involving renewable energy sources in labview environment". Kumyzbaeva S., Stoyak V.V., Rakhimov K.E., Collection of Proceedings,
5. XIV Annual Conference of National Instruments. With the report "Development of a Hybrid Autonomous System of Integrated Power Supply Based on Renewable Energy Sources and a Trigeneration Plant" Lozhkina EE, Khan SG, Kumyzbaeva SK Collection of works. - 2014

And also at the World Congress of Engineers and Scientists WSEC-2017 with the personal participation of the author.

Publications. The main provisions of the work are presented in 9 publications, including 3 editions recommended «ККСОН МОН РК» (Committee on control in the field of education and science of the Ministry of education and science of the Republic of Kazakhstan), in the journal "Journal of Engineering and Applied Sciences" with cites per doc 0.324, included to database Scopus, in 5 international scientific conferences and forums, as well as in two applications to the Eurasian

Patent Organization (EAPO) for obtaining patents for invention: 1. №201700572 - "Combined heat exchanger"; 2. № 201800008 - "Geothermal polygeneration plant".

Volume and structure. The thesis contains an introduction, 4 sections, conclusion, references. The thesis is set out on 118 pages of computer kit, including 69 figures, 26 formulas, 25 tables, a list of literature from 110 titlesб 1 appendix.

In introduction, the urgency of scientific work is revealed, the problem under investigation is specified. The main idea, scientific novelty, reliability of the work, practical value, provisions to be protected, personal contribution of the author, as well as testing results and publications.

The first section of the thesis presents a review and analysis of existing autonomous sources of energy supply. Modern energy trends. The role and place of autonomous and distributed complex generation in the world practice and economy of Kazakhstan. Involvement of RES in distributed generation. An analytical review of the existing cogeneration plants, as well as the efficiency of the use of heat pumps. Formulated the concept of the use of one-piece trigeneration plants. According to the goal, research objectives are formulated.

The second section presents the specifics of the joint generation of electricity, heat and cold in the MTGP. Presented developed generalized technical structure and the dynamic simulation model ASCES-MTGP, which consists of individual models: power characteristics of an internal combustion engine, an electric generator, a compressor heat pump, as well as a dynamic model of the energy characteristics of a system of geothermal reservoirs. The description of the developed system for optimizing the structure and composition of ASCES-MTGP, as well as methods of intelligent control of the operating modes of ASCES-MTGP. The created specialized software product.

The third section presents the results of experimental studies on the test bench, with a capacity of 6.4 kW and a pilot plant with a capacity of 10.4 kW. Model calibration is provided..

The fourth section presents the results of numerical studies on the complex dynamic simulation model created by ASCES-MTGP. A comparative analysis of the energy and environmental efficiency of the use of ASCES-MTGP for five climatic zones of Kazakhstan carried out in comparison with the monogenerating and cogeneration equipment (annual fuel costs and annual emissions of CO2 for a residential building). A comparative economic calculation of the use of MTGP on various fuels (diesel, natural gas) presented as an autonomous source of power supply is compared with several types of mono-generating equipment . The cost of 1 kW of energy is calculated for ten years of operation, taking into account inflation.

In conclusion, the main results and conclusions on the thesis presented.