ABSTRACT

of the dissertation for the degree of "Doctor of Philosophy" (Ph.D.) in the specialty 6D070200 - "Automation and Control"

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Title: "THE ENERGY CONSUMPTION MANAGEMENT AND CONTROL SYSTEM USING NEURAL NETWORKS"

The relevance of the research.

A special focus for many countries is on energy efficiency according to the current political situation. The management of energy consumption has been in the spotlight since the beginning of the crisis, for example, in 2022, the growth in global energy demand was about 1%. For comparison, 2019 saw an increase of 5%. As noted in the Energy Efficiency Report, the growth in global energy intensity was affected by the Covid-2019 pandemic. In 2020-2021, the annual increase has decreased to half a percent. Comparing data from 2010 and 2020, the global rate of improvement has dropped from 2% to 1.3%. According to the IEA (international energy agency) strategy "Net Zero Emissions Scenario" by 2050, it is required to accelerate efficiency improvement to 4% every year until 2030. Due to energy problems, many companies are forced to reduce their activities. Also, many people cannot meet their energy needs. According to the results of the study, the number of people experiencing problems with energy supply has grown to 2.5 billion. According to data since 2019, 160 million households live in energy poverty. Vulnerable populations often live in poor quality homes, use old electrical appliances and vehicles with poor energy efficiency. This worsens their living conditions, poses a threat to health, and increases electricity bills. In 2022, the use of coal, firewood for heating and cooking is noted. The topic of the dissertation research corresponds to two priority trends of science development in the Republic of Kazakhstan: energy and mechanical engineering; and information, communication and space technologies.

Key words: energy consumption system management, neural networks, fuzzy energy consumption model, use of renewable energy sources.

The research goal: a system for monitoring and managing energy consumption development using neural networks.

The main idea of the research is to develop an affordable energy consumption management and control system that combines the use of energy from RES and from the AC network, and the energy from RES should be used to the maximum and there should be no interruptions in power supply due to timely recharge from the network. Solar energy can be used as RES in the Republic of Kazakhstan, because the country has a huge potential - the amount of solar radiation is 1300–1800 kWh per square meter per year, wind energy is estimated at 920 billion kWh of electricity annually, as well as any other alternative sources

renewable energy. In this dissertation research, the main focus is on the use of solar and wind energy.

Research objectives:

1) Conducting a research of modern energy consumption management systems in different countries.

2) Development of a new infrastructure based on modern technologies, smart devices, advanced communications, electrothermal models of important components and advanced optimization models.

3) Use and adaptation of new management methods based on intelligent systems.

4) Development of an automated software complex for the implementation of intelligent energy saving management.

The object of the research is the energy saving management system.

The subject of the research is an intelligent energy saving management system.

The main research methods used in the work are the principles of automation, the methodology of system analysis, the theory of neural networks, fuzzy logic methods, data analysis and statistical models.

Scientific provisions submitted for defense:

1) a model of energy consumption of an autonomous building based on the application of the laws of electrical circuits to electrical processes occurring in this building, taking into account the fuzzy nature of the output data from renewable energy generators using a fuzzy neural network.

2) the results of modeling and testing a new automated system for monitoring and controlling the energy consumption system using neural networks on test and real data.

The scientific novelty of the work:

1) for the first time, a model of the energy consumption of an autonomous building was built based on the application of the laws of electrical circuits to the electrical processes occurring in this building, taking into account the fuzzy nature of the output data from renewable energy generators using a fuzzy neural network.

2) A new structure has been developed based on modern technologies, such as the use of smart devices, advanced communications, electrothermal models of important components, and advanced optimization models.

3) for the first time, an automated system was developed as a means of supporting the original infrastructure based on the use of a fuzzy neural network, which has advantages over existing solutions in terms of accuracy: the root mean square error is approximately 0.00014.

The reliability and validity of the formulated scientific provisions, the findings, results and recommendations are based on the appropriate application of the theory of system analysis, statistical methods of analysis, mathematical modeling methods, the theory of neural networks, the construction of fuzzy sets, the correct use of the principles of functioning of automated systems, as well as the implementation of the received recommendations.

The dissertation has scientific and practical significance: the developed automated system is a software and hardware automated complex brought to practical implementation, which allows analyzing the data received from sensors for rational energy consumption using renewable energy sources, taking into account the fuzziness of the system parameters and predicting the need for additional energy from the network using a neural network.

The developed model for the operation of an automated energy consumption system and other results of the work can be widely used to supply energy to both residential and industrial buildings for the use of renewable energy sources, which will contribute to energy saving and optimal energy consumption.

The results of the dissertation work are introduced into the educational process of D. Serikbayev East Kazakhstan Technical University in the educational program for the preparation of doctoral and undergraduate students "Automation and Control" for the disciplines "Fuzzy Algorithms and Control" and "Software for Industrial Controllers" (Act of implementation of the D. Serikbayev East Kazakhstan Technical University, May 5, 2022).

Production tests of the assembled installation for power supply of the facility located at Polzunov st., 74, in "OpenTech Plus" LLP. 20 panels were installed on the roof of the barn on the territory of the facility, an automation cabinet was assembled with all the necessary equipment. The tests carried out showed the operability of the installation. Test period: August 2022 (OpenTech Plus LLP, production test report 2022/1 dated 08/22/2022).

The personal contribution of the author of the dissertation research consists in the independent formulation of the problem, the identification of the purpose and objectives of the study, the search and justification of the possibilities and methods for solving them, as well as the scientific and practical results obtained during the study, the analysis and generalization of the final conclusions were made personally by the author of the dissertation.

Publications. A total of 12 papers have been published on the topic of the dissertation, of them: 1 article in a journal peer-reviewed by Scopus, which has a Q3 quartile for technology and interdisciplinary works and a percentile of 0.71; 3 articles in journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Republic of Kazakhstan, 7 articles in the proceedings of international conferences near and far abroad and the Republic of Kazakhstan and 1 certificate of state registration for the copyright object.

Approbation of work. The main results of the dissertation were discussed and reported at international conferences:

14th International Symposium on Applied Informatics and Related Areas, (Szekesfehervar , Hungary, 2019);

VI International scientific and technical conference of students, undergraduates and young scientists "Creativity of the young innovative development of Kazakhstan", (Ust-Kamenogorsk, Kazakhstan, 2020);

15th International Symposium on Applied Informatics and Related Areas, (Szekesfehervar, Hungary, 2020);

VII International scientific and technical conference of students, undergraduates and young scientists "Creativity of young people for innovative development of Kazakhstan", (Ust-Kamenogorsk, Kazakhstan, 2021);

17th International Symposium on Applied Informatics and Related Areas, (Szekesfehervar, Hungary, 2022);

XVII International Scientific and Practical Conference. Multidisciplinary academic notes. Theory, methodology and practice" (Tokyo, Japan, 2022);

XIX International scientific and practical conference "Modern problems in science" (Vancouver, Canada, 2022).

The main scientific results proved in the dissertation, as well as in articles on the research topic, include:

Energy consumption model of an autonomous building based on the application of the laws of electrical circuits to the electrical processes occurring in this building, taking into account the fuzzy nature of the output data from renewable energy generators using a fuzzy neural network. This model takes into account seasonality, and also distinguishes between working, weekend and holiday load profiles by building a perceptron for the load profile of weekdays and a second perceptron for predicting the weekend profile. Confidence intervals were calculated using a sample of 100 items.

New infrastructure based on state-of-the-art technologies such as the DSE controller, smart devices, advanced communications, electrothermal models of critical components, and advanced optimization models. This infrastructure allows real-time management and control of various components connected to the building. Thus, the burden of integrating new loads is reduced and further increases the integration of renewables into the distribution system. In addition, it allows the implementation of various building optimization functions to maximize the benefit for consumers. All this without any inconvenience to the end user and without loading / overheating the distribution transformer.

Automated-software complex for the implementation of intelligent energy saving management as a result of modeling and testing a new automated system for monitoring and controlling the energy consumption system using neural networks on test and real data.

It is proposed for implementation in practice: certificate of state registration for the object of copyright No. 16772 dated April 20, 2021. Type of copyright object: computer program. Name of the object: "SmartHouse smart house energy management system" Authors: O.Ya. Shvets, A.V. Shokarev, **A.A. Naizabayeva**, A. T.Toleugazyuly.

The structure and scope of the dissertation. The study consists of an introduction, three main sections, a conclusion, a list of 150 references on 122 pages, including 6 tables, 62 figures, 9 appendices.