

ABSTRACT

of the dissertation by **Telbayeva Shynar Zarykbekovna**
on the topic «Research and development of methods and algorithms
for operational control of power consumption at mining enterprises»
submitted for the degree of Doctor of Philosophy (PhD)
in the educational program 8D07103 – «Electric power engineering»

The dissertation is devoted to the research and development of methods and algorithms for operational control of power consumption at mining enterprises.

The dissertation aim is to improve the system for monitoring and controlling power consumption modes at mining enterprises during operation by developing forecasting methods and control algorithms for energy-intensive technological installations based on continuous monitoring of power consumption modes.

Research objectives:

- analysis of methods for calculating power consumption parameters;
- research and analysis of power consumption modes in Karaganda Region and a coal mine;
- analysis of methods for forecasting power consumption modes;
- research and development of a model for operational monitoring of power consumption modes;
- development of a methodology for determining decision-making time limits;
- research and development of mathematical models of power consumption modes for energy-intensive installations and the mine as a whole;
- development of basic requirements for an automated system for technical metering, monitoring, and control of power consumption modes, enabling the implementation of models and algorithms.

Research methods:

The research methodology is based on a set of scientific methods aimed at studying the structure and power consumption modes of coal enterprises, developing mathematical models and optimization algorithms, and creating predictive models. In particular, the following methods were used:

- analytical and theoretical methods: the regulatory documents of the Republic of Kazakhstan governing the issues of power supply and electricity consumption at industrial enterprises were analyzed. A study of the power consumption modes of Karaganda Region and mining enterprises was carried out, which made it possible to determine the qualitative and quantitative characteristics of electricity consumption at coal mines;
- methods of system analysis and modeling: a mathematical model of the information flows within the power consumption system was developed. Based on probability theory and analysis of pulse flows, mathematical models were created for technological groups of power consumers (with uniform, normal, and pulse-type distributions), as well as a generalized model of power consumption for mining enterprises;
- methods of forecasting and intelligent data analysis: research and testing were conducted on three power consumption forecasting models: a seasonal ARIMA

model, a simple exponential smoothing method, and a neural network with a long short-term memory (LSTM) architecture;

- methods of optimization and control: a methodology was developed for determining the critical decision points in managing power consumption modes. A structural scheme of dispatch control priorities in the case of load deviations was proposed, as well as control algorithms for consumer-regulators.

Scientific provisions submitted for defense:

- principles and methods of continuous technical accounting and monitoring of power consumption parameters;

- methods (methodology) for forecasting power consumption modes;

- mathematical models of powers consumption modes;

- criteria for optimal control of power consumption modes;

- control algorithms for energy-intensive installations.

Scientific novelty of the dissertation:

- mathematical models were developed for each type of load mode (uniform, normal, and pulse), as well as a generalized model of power consumption for a coal mine. The proposed models can be used for analysis, operational forecasting, and long-term planning of power consumption modes for the mine as a whole, its supply centers, technological processes, and individual consumers.

- a LSTM neural network model was developed for forecasting power consumption modes, which allowed for an adequate representation of the complex dynamics of actual power consumption modes. This was confirmed by the best forecasting indicator, MAPE (5.37%), on the test dataset;

- a methodology for determining the critical decision points in managing power consumption modes was proposed;

- an interactive model for preliminary configuration of the control system during interaction between the dispatcher and the management system was proposed;

- principles and control algorithms were proposed for regulating consumers, which are technological installations of the coal mine.

- development and implementation of an automated power consumption accounting system was proposed, which will enable comprehensive monitoring, analysis, and optimization of power consumption modes at coal enterprises. Based on the conducted study of the power consumption structure of the Kostenko coal mine, a list of objects subject to technical electricity accounting was provided.

Practical significance of the obtained results:

- solutions for technical accounting and control of power consumption parameters were developed;

- models and algorithms for predicting power consumption modes were developed;

- algorithms for controlling energy-intensive installations were developed;

- criteria (power, electric power, power factor) for optimal control of power consumption modes were developed;

- a set of technical requirements for an automated system for technical accounting and management of power consumption modes was developed.

The degree of reliability of the research results:

The results of the dissertation research were introduced into the educational process of the NAO «Karaganda Technical University named after Abylkas Saginov» when studying the discipline «Automated power supply management» of the educational program 6B07107 «Electric Power Industry», which is confirmed by the act of introducing sections of the dissertation work into the educational process.

The results obtained in the dissertation work were also presented and discussed at a meeting with the Chief Power Engineer of «Karaganda Qomir» LLP, following which an act of introduction into production was issued.

The practical significance of the research results was confirmed by the receipt of utility model patent No. 11600 dated 12/26/2025 «Coal mine drainage control system».

Personal contribution of the author consists in development of mathematical models for the distribution and forecasting of power consumption at a coal enterprise, creation of a model of information flows within the power supply system, analysis of actual load data, as well as development of algorithms for optimization and dispatch control of power consumption modes. The results and recommendations obtained by the applicant can be used in implementation of an automated system for technical accounting and management of the mine's power consumption as functional subsystems ensuring increased energy efficiency and stability of the power complex. In co-authored published articles, the author is responsible for the results of experimental studies, analysis, preparation, design, submission, and support of the materials.

Approbation of the work. The main scientific results of the dissertation work have been published in 9 publications:

- in publications included into the scientific database Scopus, 2 article:

1. Development of mathematical models of power consumption at coal plants. Eastern-European Journal of Enterprise Technologies, Vol. 5 No. 8 (131) (2024), pp. 22–32, DOI: <https://doi.org/10.15587/1729-4061.2024.313932> (процентиль – 43);

2. Development of a forecasting model for optimizing energy consumption at coal enterprises. Eastern-European Journal of Enterprise Technologies, Vol. 6 No. 4 (138) (2025), pp. 26–35, DOI: <https://doi.org/10.15587/1729-4061.2025.345073> (процентиль – 54);

- in journals recommended by the Committee for Quality Assurance in Science and Higher Education of the Ministry of Science and Higher Education of the Republic of Kazakhstan: – 3 articles:

1. Исследование системы электропотребления угольной шахты. Труды университета. - Караганда: КарТУ имени Абылкаса Сагинова, 2024. – №1. – С. 445-451.

2. Исследование графиков электрической нагрузки в условиях карагандинского угольного бассейна. Вестник Торайгыров университета. Энергетическая серия. - Павлодар, 2024. – №1. – С. 6-21.

3. Прогнозирование электропотребления в условиях угольной шахты. Вестник Торайгыров университета. Энергетическая серия. - Павлодар, 2025. – №2. – С. 353-365.

- in international scientific conference works, 4 articles:

1. Повышение эффективности использования газовых котельных в угольных шахтах в угольной шахте // Труды Международной научно-практической конференции «XV Сагиновские чтения. Интеграция образования, науки и производства». – Караганда, 2023. - Часть 1. - С. 436-438.

2. Исследование графиков электропотребления угольной шахты // Труды Международной научно-практической конференции «XVI Сагиновские чтения. Интеграция образования, науки и производства». – Караганда, 2024. - Часть 1. - С. 612-614.

3. Разработка алгоритма управления конвейерных установок в режиме потребителей-регуляторов электрической нагрузки // Труды Международной научно-практической конференции «XVII Сагиновские чтения. Интеграция образования, науки и производства». – Караганда, 2025. – Часть 1. - С. 698-700.

4. Automated system for early detection of underground fires // XIV наукова конференція «НАУКОВІ ПІДСУМКИ 2025 РОКУ». Збірка наукових тез. – Харків, 2025. Р. 24. ISBN 978-617-8360-24-5.