Critical Infrastructures in the Digital World

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FEATURES OF NEURO-ASSISTANTS DESIGN IN THE KNOWLEDGE ECOSYSTEM

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The application of AI in the energy industry, as a critical system, faces a number of specific problems, including data uncertainty in modeling energy processes, as well as the need to ensure high reliability and safety of systems [1]. Thus, the urgent problem is the development of such methods and approaches that will enable effective use of AI potential to solve problems in the energy sector, while minimizing the associated risks.

One of the relevant tasks of this direction is the development of a neuroassistant capable of answering user questions, performing text summarization, etc. The core of this kind of systems are large language models (LLMs) whose answers are formed solely on the basis of templates and information learned during training. Nevertheless, such models are limited by the amount of data on which they have been trained, which often leads to the generation of superficial answers and insufficient depth of topic coverage [2]. As a solution to this problem, an approach called Retrieval-Augmented Generation (RAG) is proposed to address this problem by providing connections to external data as needed during response generation. The way this system works is that when a query is received, the RAG system initially extracts relevant information from large data sets or knowledge bases (KB) and then uses it to generate a more accurate response. This capability not only significantly improves model performance, but also fundamentally transforms approaches to answer generation. As a result, language models are able to generate answers that are not only accurate, but also grounded in relevant data.

However, one of the limitations that prevents the RAG approach from being applied without modifications to tasks in the knowledge ecosystem in the energy sector is the fact that the data used for context selection are often heterogeneous and require different processing approaches [3]. As in the standard architecture for building neuroassistants, in the proposed scheme the “input” block is a user query in natural language. Then, the query enters the preprocessor block, in which, depending on the task, it goes through the stages of tokenization, lemmatization, division into semantic blocks (chunks) and conversion into vectors, either sequentially or in parallelly [4].

In addition, one of the key challenges in the development of neuro-assistants based on the RAG architecture is the efficient (“quality”) management of the KB, the data from which represent the main source of information and directly influence the generated response that the system user will receive. As stated earlier, in the proposed system, the knowledge base is a structure consisting of components of different types, such as ontologies, taxonomies, knowledge graphs, text documents and other data formats, which requires different approaches to their processing and utilization. The relevance and validity of this data determines the effectiveness and practicality of the neuroassistants work as a whole, which is particularly important in the energy field. The processed query is then passed to the “engines” block. The term “engine” means a software solution that allows extracting information from a certain part of the knowledge base. The next stage is summarization of the gained context (knowledge) from the

KB. The processed context together with the initial user request is transferred to the LLM, where the answer is generated on the basis of the obtained knowledge. The architecture of the neuroassistant is shown in fig. 1.

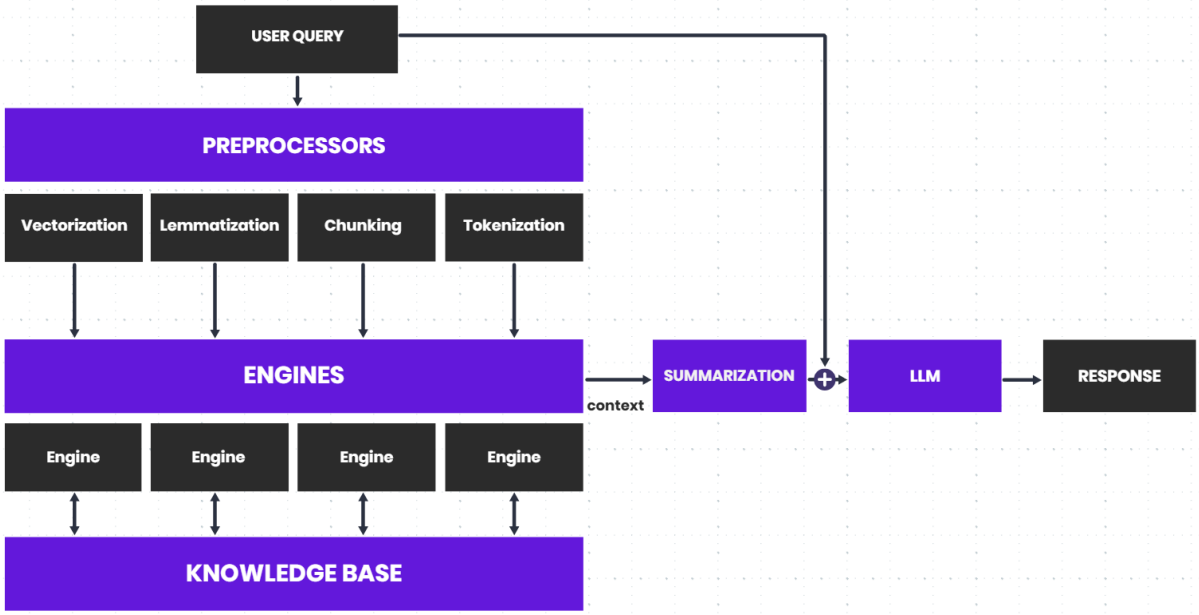

Fig. 1. Neuro-assist architecture in the knowledge ecosystem in the energy industry

In conclusion, the proposed method of usage of modified RAG architecture, as well as a special approach to working with a knowledge base consisting of various unstructured data will serve as a solution to the main problems of AI usage. The combination of the above methods will allow taking into account the features of the subject area, which will ultimately increase the efficiency and quality of the neuroassistants work.

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OPTIMIZATION OF FOOD PRODUCTS PRODUCTION TAKING INTO ACCOUNT THE FEATURES OF THE ACTIVITIES OF THE PRODUCER

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The creation of models for optimizing the production of food products, taking into account the specifics of the activities of the commodity producer, is an important tool for increasing the efficiency of resource use and planning the development of an agricultural commodity producer.

Different categories of farms can be divided into groups by production, processing processes and product sales.

For organizations that include the production, processing and sale of products, such as the agricultural joint-stock company "Belorechenskoye", the model should reflect all of the listed aspects. The products produced in the fields and farms can be used by the enterprise for internal needs and for sale to consumers. In addition, the produced resources are necessary for processing and obtaining products of various types, which are sold through a network of stores. In general, the organization seeks to obtain maximum profit. At the same time, a similar vector characterizes the production and processing of products associated with sales. In other words, the general model for obtaining and selling products contains modules for each element of the system. It should also be borne in mind that there are several divisions within one enterprise, which suggests the use of multi-level models based on the principle of consolidation.

The second group of organizations, which includes, for example, the agricultural joint-stock company "Primorsky", carries out production activities and is partially engaged in the processing of products. At the same time, such organizations can interact with other categories of farms - personal farmsteads and peasant (farm) enterprises. Unlike the first, the second group of farms is more dependent on external factors. For their effective work, it is necessary to build the right relationships with producers of other categories. In this case, multi-criteria problems describing the interaction of the main organization and other farms, both deterministic and uncertain, are applicable.

A large number of farms are related to producers of agricultural products, which are subsequently used for their own maintenance and marketing in order to make a profit for the development of production. From the point of view of the structure of mathematical models, the description of the activities of such producers is less labor-intensive compared to modeling the receipt of products for the first and second groups of organizations. As a rule, industry models and their combination under uncertainty are applicable for this case.

To build mathematical models taking into account the specifics of the activities of agricultural producers, the tasks of multilevel parametric programming with uncertain characteristics, multicriteria problems, and stochastic programming are applicable. It is proposed to obtain results describing favorable and unfavorable situations, as well as to find solutions under the influence of extreme events that cause significant damage to the activities of agricultural producers.

The variety of models depending on the specifics of the selected groups of agricultural organizations contributes to an adequate mathematical description of the receipt of food products in accordance with real situations for solving management problems. At the same time, planning of various aspects of the agricultural producer’s activities, from production to sale of products, is improved.

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PARALLEL VERSION OF THE CURVILINEAR VARIATIONAL METHOD FOR NONCONVEX EXTREMAL PROBLEMS

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The curvilinear variation technique has been known for a long time in the practice of numerical optimization. For example, it is used to overcome the undesirable effect of "non-improving directions" generated by the classical Newton method [1]. Known techniques for ensuring relaxation of second-order algorithms used either the "broken-line" technique, when the motion starts along a gradient and then, having broken, goes to a "Newtonian point", or the technique with a smooth multidimensional curve with similar beginning and end. However, such approaches have not been used for optimal control problems for a long time. For the first time, a dynamic optimization algorithm using this idea was proposed in [2].

The linear variation of the control, which dominates in numerical methods, after passing through the differential operator, inevitably leads to curvilinear mappings on reachability sets. On the other hand, curvilinear methods of control variation are obviously much more flexible than linear ones, which can be included as a special case. The situations arising in this case when the constructed controls exceed the admissible bounds can be easily corrected by applying geometric projection operators.

We have already made attempts to use convenient properties of curvilinear variation to construct parallel technologies in the optimal control problems. However, in our opinion, the potential of curvilinear variational parallelism has not been fully revealed yet. In this paper, we discuss a finite-dimensional optimization method based on the proposed approach. The basic idea of the algorithm is to construct curves originating from the currently optimized point and directed tangentially along the gradient to some randomly generated reference points located at a sufficient distance. The use of proposed variations can provide both local improvement of the current search point (if the gradient is non-zero) and serve as a tool for non-local (global) search. The parallel variant of the algorithm relies on the applied method of one-dimensional search, using the idea of "shrinking grids": at each iteration a random non-uniform grid is generated, the function values in its nodes are calculated in parallel mode; then a new grid is generated in a some small neighborhood of the best approximation found, etc.

The conducted numerical experiments have confirmed the operability of the proposed approaches.

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MODEL OF OPTIMIZATION OF LAND USE IN PASTURE LIVESTOCK HUSBANDRY

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One of the problems of pasture livestock farming in Mongolia is pasture degradation as a result of irrational use of resources and a significant increase in the number of animals. According to statistics, approximately 30% of pasture areas are subject to this process. Some researchers draw attention to climate change, which is becoming drier and hotter. Obviously, this also affects the condition and change of pastures. The Government of Mongolia has identified the main directions for protecting pasture lands from degradation, which include regulating the number of livestock and monitoring the assessment of pasture use.

To solve this problem, mathematical modeling methods can be used. In particular, models for optimizing the use of pastures to make a profit, taking into account damage to the environment are applicable here. The model for optimizing the use of pastures that we propose is based on the ecological-mathematical model described in the monograph (Ivanyo Ya. M., Kovaleva Eu. A. Ecological and mathematical modeling of agricultural production. Molodezhny: Publishing House of Irkutsk State Agrarian University, 2024. 118 p.).

The modification of the model assumes taking into account the features of pasture livestock farming. The model describes the process of pasture livestock farming within one year. The target function includes three components characterizing the profit from feed when grazing animals, the profit from the prepared feed and the profit from the number of animals. At the same time, the terms contain the coefficients of the negative impact of the process of fattening animals on the state of land resources, describing erosion processes and soil compaction from trampling pastures by animals. The desired variables are the areas of forage crops of different composition.

The volumes of production associated with the number of different types of farm animals are used as constraints. In addition, the conditions for the area of pastures for grazing and forage harvesting are taken into account. An important constraint is the link between feed and the number of animals, as well as compliance with the regulatory conditions for the concentration of animals in the territory. Labor force constraints determine the number of personnel required to perform work in accordance with technological processes. The problem of pasture livestock farming is providing animals with water. This must be taken into account in the constraint. The presence of hilly terrain and trampling of pastures by animals contributes to deflation, soil salinization and an increase in surface runoff. Regulation of the indicators of these phenomena is also taken into account in the constraints.

The result of the modeling is the maximum profit from the optimal use of pasture areas with an assessment of damage from trampling of the soil by animals and erosion processes. The coefficients of negative impact on the environment included in the target function can be obtained in the form of expert assessments or using maps characterizing the erosion of the soil in different areas of Mongolia.

Thus, the proposed model allows managing the grazing process in pasture livestock farming to reduce damage from soil degradation. The model can be modified to take into account random environmental factors and variability of climate characteristics.

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MODELING THE EFFICIENCY OF UNIVERSITY ACTIVITIES USING AN ELECTRONIC INFORMATION AND EDUCATIONAL ENVIRONMENT

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A modern university is a complex social system whose task is not only to train highly qualified specialists, but also to ensure the development of science, culture and society as a whole. In a highly competitive environment, the university management needs methods that allow assessing and improving the efficiency of the university. Mathematical modeling can be used as such a method, which allows solving complex problems with many factors, including uncertain ones, and dynamic changes in the system.

One of the mandatory conditions for the university's activities is the availability of an electronic information and educational environment (EIEE). This environment performs functions, first of all, the implementation of the educational process - interaction between a student and a teacher. In addition, it allows determining student ratings in accordance with the areas of training for bachelors, masters and specialists. In the electronic information and educational environment, monitoring of the work of postgraduate students of the university is carried out.

The expansion of the functions of the electronic information and educational environment is associated with monitoring the accreditation indicators of the university for various educational programs and assessing the prospects for their effectiveness. For this purpose, a matrix model for determining integral indicators relative to basic indicators is proposed, the result of which is a rating of educational programs and the identification of weaknesses in the quality of applicants, target recruitment, educational process, staffing and employment of graduates. In particular, Irkutsk State Agricultural University carries out educational activities for more than 40 educational programs of higher education, which are assessed by eight accreditation indicators.

Integrated indicators of educational program assessment are related to the educational process, research activities and relationships with founders and industrial partners. Therefore, the final results of educational program implementation depend on the management of the university's activity processes throughout the student's education period.

To improve management processes, methods for forecasting and assessing probable situations are proposed. When solving such problems, accreditation indicators are divided into groups: 1) average score of the unified state examination; 2) information on graduates, target recruitment and employment; 3) data on scientific and pedagogical workers; 4) availability of an electronic information and educational environment and internal independent assessment of the quality of education. To forecast and assess probable situations for their management, naive, trend, autoregressive models and a model for comparing the subsequent and previous levels with an indication of the achievable result, as well as machine learning methods and neural networks are proposed.

Examples of using different models and methods for forecasting and probable assessment for the first three groups of indicators, as well as for auxiliary characteristics describing the university's activities are given. The results are obtained using the data of the Irkutsk State Agricultural University as an example and are used to improve management decisions. To this should be added the possibility of using expert assessments as the results of surveys of students and faculty to adjust various aspects of the university’s development.

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ARCHITECTURE OF A CLOUD PLATFORM FOR STORAGE AND PROCESSING OF MAGNETOTELLURIC SOUNDING MONITORING DATA

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The magnetotelluric sounding (MT) method was developed in 1950 by Soviet geophysicist A.N. Tikhonov and later expanded upon through research by French scientist L. Cagniard. Today, MT is widely used in geophysics to study the Earth's deep structure. This method is a type of induction frequency sounding with a non-controlled source of electromagnetic fields. The MT field is generated by natural sources, including ionospheric and magnetospheric currents, thunderstorm activity, and solar wind. Due to the skin effect, high-frequency components of the electromagnetic field attenuate rapidly, providing information about near-surface layers, while low-frequency oscillations penetrate to greater depths, enabling the study of the deep structure of the geolectric section [1, 2].

MT plays a key role in investigating geodynamic processes associated with earthquake preparation and occurrence. Modern studies demonstrate that precursory changes in the Earth's interior prior to seismic events are reflected in electromagnetic sounding data. MT reveals the spatial distribution of deep electrical conductivity, which serves as an indicator of thermodynamic conditions in the crust and upper mantle. Long-term MT monitoring confirms the correlation between seismic activity and conductive geolectric heterogeneities in the crust and mantle [3].

MT data consist of large volumes of time series of electric and magnetic fields, requiring specialized processing. This necessitates cloud-based solutions that provide scalable storage, high-performance computing, and access to analytical tools. This paper proposes an architecture for a cloud platform tailored to the specifics of MT data.

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DIGITAL HEALTH LITERACY: RUSSIAN PROBLEMS

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Medical literacy is a person's ability to extract and perceive information related to health issues, make decisions that are appropriate to the situation, and follow treatment instructions. Thanks to the Internet, there is more medical information available now than at any time in human history. Most people use Internet as an adviser on both the treatment of various diseases and a healthy lifestyle. Digital health literacy is the use of health literacy competencies in a digital environment to enable the safe and effective use of information and communication technologies. Stakeholders must be able to search for medical information, understand it, apply digital solutions in the interests of their health, use modern IT capabilities (mobile health care, web applications, smart sensors, etc.). Stakeholders are patients and family members who care for them, and those people who care about their health, do not want to become patients and lead an active lifestyle. On the one hand, thanks to digital literacy, people can ensure that they receive timely, high-quality medical care without financial expenses, avoiding the choice between receiving medical services and meeting basic needs [1]. On the other hand, after reading information articles and forums, they can make diagnoses and prescribe treatment for themselves and their loved ones. In such situation, maintaining common sense becomes increasingly difficult.

In the context of a crisis of confidence in the healthcare system in the Russian Federation, when more than half of Russians do not trust the experience and knowledge of doctors, and also do not follow their recommendations, trust in Internet is becoming greater than living physician. Thus, almost 40% of respondents doubt the diagnosis and physician's prescriptions are most often checked in the Internet [2]. Constant search for information, blind trust in forums and advice on the Internet create additional stress on the mental state, especially in conditions of chronic stress due to health problems. A low level of digital literacy combined with information noise increases anxiety and depression. Patients with high digital literacy are more knowledgeable about disease management and find helpful resources for support. They more often use adaptive coping strategies (seeking help, following medical recommendations, participating in supportive communities). Digital literacy helps manage both physical and psychological well-being [3].

It should be noted that modern approaches in medicine are shifting towards increasing the patient's role in managing their health. Patients become active co-author of their health. The higher their digital literacy, the more verified and reliable information they will have, and the more constructive their involvement in the process of treatment and medical decision-making will be. Given the limited time allotted for an appointment at the clinic, the doctor, if necessary, can redirect the patient to a digital resource, where he will receive complete and understandable information about his disease and lifestyle recommendations. It is important that stakeholders use digital resources, such as apps or online communities, curated by leading healthcare professionals to ensure they are relevant and credible.

Currently, there are over 97 thousand health apps available for download, which is a stunning result of mobile health (MHealth), 70% of these apps are dedicated to sports and health, 30% of them help in professional medical monitoring and provide access to data on the patient's health, images of studies performed, and prescribed drug therapy [4]. Using wearable devices, the mobile application remotely exchanges diagnostic data between the doctor and the patient, which allows for the early detection of chronic diseases. When using MHealth mobile

applications, through remote monitoring of patients with chronic diseases and communication with doctors in real time, healthcare costs can be reduced by 15%, as the number of face-to-face consultations and hospitalizations will decrease.

Thus, digital health literacy will directly impact the ability of stakeholders to make informed decisions and improve the efficiency of the healthcare system. Further research into the connection between digital health literacy and the ability to effectively manage one's condition will provide scientific evidence for educational and preventive programs. Training the population to work with medical information is necessary, which should be a new modern task of preventive medicine.

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INVESTIGATION OF AGE DYNAMICS OF POPULATION MORTALITY OF THE INDUSTRIAL CENTER FROM DISEASES OF THE CIRCULATORY SYSTEM DURING THE PANDEMIC

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The paper explores the influence of air pollution on the dynamics of mortality from diseases of the circulatory system (CVD) during the pandemic. One of the significant risk-modifying factors affecting the dynamics of morbidity and mortality from CVD is atmospheric air pollution. The negative impact of suspended particles on the body is currently beyond doubt, with PM2.5 affecting mainly the respiratory system, and larger fractions of PM10 affecting the cardiovascular system.

The city included in the list of the most polluted cities in Russia was chosen as a model settlement due to the location of large stationary sources of emissions on its territory, which have a significant impact on public health [1]. The study was carried out using data from the background period of 2017 and the pandemic period of 2021.

The identification of age–related risk groups for CVD mortality was carried out using exponential type models: $y = \beta \cdot e^{\alpha x}$, where y characterizes the age–related mortality rate (MR), x is the age of the observed patients, and β is the constant reflecting the tendency for MR levels to increase with age in individuals. The search for the α and β coefficients was performed using OPTCON software [2], focused on solving non-convex optimization problems, including problems of ultra-large dimensions.

The obtained results allowed us to demonstrate changes in trends of age- specific mortality during the background period and during the pandemic. It was revealed that during the pandemic, the level of excess mortality associated with PM10 air pollution decreased [3].

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CONCEPTUAL FRAMEWORK FOR LOGGING A COMPLEX ACCOUNTING INFORMATION SYSTEM

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INTRODUCTION. The need for a chronological record of the most significant information about the operation of computer equipment arose back in the early 80s. Since then, mechanisms for recording events occurring in a computer system, messages about problems, failures, errors, or simply information about current operations, have become an integral part of modern information processing technology.

Such events can occur in the operating system or in other software, particularly for web search - these are events of interactions that occurred during a search session between the search engine interface and users who search for information on the Internet. Traditionally, such a format of recording events is designed as an *event log*.

For information systems that actively use database management, it is important to maintain a *transaction log*, where changes to stored data are recorded. Thus, database management systems usually have both general event logs and transaction logs.

Basically, the information stored in various event logs is used for human reading, analysis and finding solutions to problems when using a computer system. At the same time, event data is increasingly becoming a source of knowledge on the basis of which research can be built, an audit can be carried out for the purpose of subsequent analysis of user behavior. Such technologies for analyzing user and entity behavior are collectively called UEBA (User and Entity Behavior Analytics).

Today, UEBA is an integral part of modern cybersecurity systems. The main purpose of such systems is to identify deviations from the normal behavior of users and entities in the network. Such solutions have become quite widely used in the banking sector to analyze user behavior and prevent money laundering and other illegal activities.

Thus, it can be assumed that behavioral analytics, as one of the areas of artificial intelligence, can become one of the most promising areas for the development of modern transactional systems, especially if we pay attention to the widely used accounting information systems (AIS), which are poorly studied in this regard. AIS are application systems that accumulate significant volumes of transactional data on user actions in log files. At the same time, due to their specificity and functional complexity, these systems do not yet have sufficient intellectual potential for analyzing user behavior. One of the factors hindering the development of intelligence is conceptual uncertainty, for the reduction of which this study sets the task of developing the main conceptual apparatus for logging AIS.

EVENT RECORDING MECHANISMS. To create logging logs, various mechanisms, languages, and formats for recording information are used, in particular:

The mechanism of recording logs in a text file is the most understandable and common approach, when each event is recorded on a separate line. Such logs are easy to read by opening the file in any text editor.

A mechanism for creating a complex multi-stage recording structure, when one event is described by several lines. To read this type of file, special programs are used to make it easier for a person to perceive complex information. Binary - the most complex mechanism for recording files, when logs are processed by the same software as the software that records them. Special applications are also used to read them.

The use of DBMS in logging mechanisms has an obvious disadvantage, significantly slowing down the operation of the database due to the intensity of logging, especially in cases of poorly thought-out logging settings.

BASIC CONCEPTS OF LOGGING OF THE ACCOUNTING INFORMATION SYSTEM.

The System is a complex multi-component and multi-functional application information system.

Logging is the process of recording and storing information about events related to the activity of System objects and its users (see Figure 1).

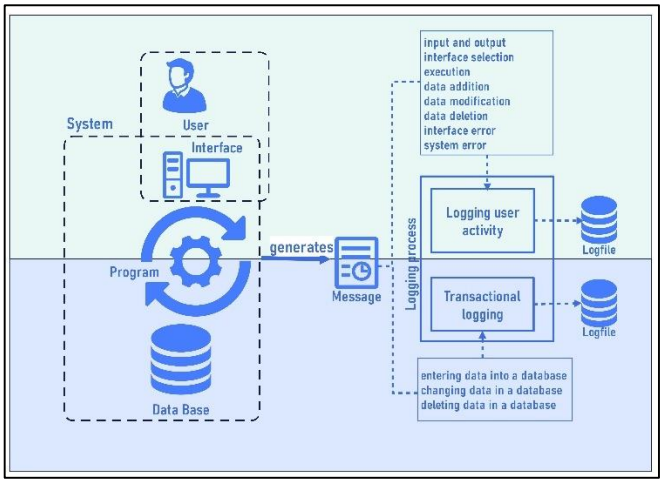

Fig. 1. Event processing process

Event is a System message informing the external environment about the results of user interaction with the System interface and the interaction of its objects.

System objects: programs and functions, interfaces, database (DB).

Interaction of objects can be of two types:

1) internal – between objects (programs, interfaces and DB);

2) external – between the user and the System interface.

User activity – interaction of the user and the System interface.

DB activity – interaction of the System programs with the DB.

Logging levels (log types):

- **user activity logging** - the process of chronologically recording the results of interaction between the user and the System interface;
- **transactional logging** - the process of chronologically recording the results of database requests.

Results of interaction between the user and the System interface:

- login and logout from the System;
- selection of the System interface;
- execution (functions, subroutines of the System);
- adding data;
- changing data;
- deleting data;
- error in the System interface;
- system error.

Results of accessing the DB:

- entering data into the DB table;
- changing data in the records of the DB table;
- deleting data from the DB table.

Each type of log has its own recording log – a log file.

Log file - a chronologically filled log file with data on events describing the results of interaction between System objects and (or) its users.

Log file format - specification of the structure of event data, including fields describing the commands of the System and the consequences of executing these commands.

Description of a system object - a semantic structure with a different format for presenting changes for each type of System object.

Transactional command of the system - a semantic structure reflecting the meaning of a single program access to a database table, within the framework of the DB activity.

Database table - a semantic structure reflecting a set of related and structured data with the results of the DB activity.

User activity frame is a semantic structure based on command slots and System objects and reflecting a certain complete image of the user activity result. The frame serves as the simplest element of meaning formation in the user's sequential behavior, since it allows one to understand the meaning of his action, to trace its relationship with other actions (previous and subsequent).

CONCLUSION. The conceptual apparatus of logging proposed in this study is primarily aimed at arguing our idea of the cognitive nature of the event data stored in log files that describe the results of interaction between the System and its user. The cognitive nature of big data on the meaningful (intellectual) actions of the UIS user is that his actions, as a person, reflect his mental representation of the situational use of the IS in the surrounding reality. In addition, what is especially important, the desire for generality of the situational cognitive model may be suitable for describing (modeling) many other similar situations, images, i.e. for explaining and predicting the behavior of this or another user in a similar situational model.

ELECTRICITY CONSUMPTION IN DATA CENTERS: CURRENT STATUS AND FORECASTS

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The development of information technologies has given impetus to the emergence of new types of economic activity, such as digitalization, cryptocurrency mining, and the use of artificial intelligence technologies. According to experts from the World Economic Forum, in 2025 the amount of data produced, stored, and consumed in the world will increase threefold compared to 2020. The constantly growing volume of digital data requires the expansion and development of centers for their processing and storage.

Electricity consumption by data centers, artificial intelligence, and the cryptocurrency sector is a new significant factor influencing the prospective dynamics of electricity consumption, which was not previously taken into account.

The purpose of the work is to analyze global and domestic trends in energy consumption by information technology sector to assess its prospective electricity demand.

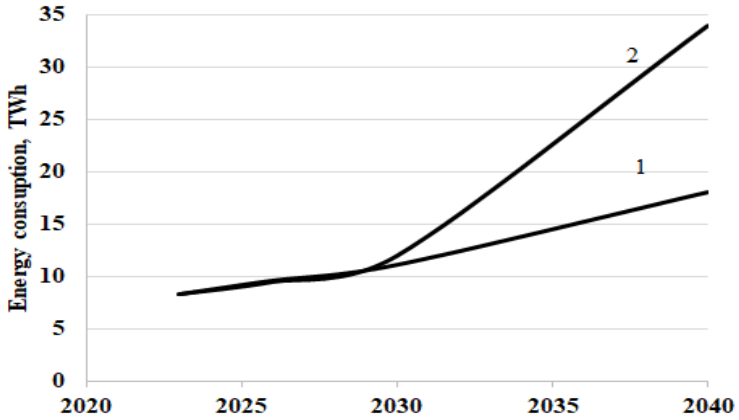
In 2014, the global data center electricity consumption was estimated about 194 TWh, or about 1% of global consumption [1], and in 2022 it was about 460 TWh, or almost 2% of total global electricity demand [2]. In 2023, 140 TWh of electricity was spent on bitcoin mining alone [3], and training the large BLOOM language model (176 billion parameters) required 433 MWh. [4].

According to the IEA forecast [5], depending on the pace of digitalization and efficiency gains, as well as trends in artificial intelligence and cryptocurrency, global electricity consumption in this area of activity may amount to 620-1050 TWh in 2026 (baseline scenario - just over 800 TWh).

According to McKinsey, in the US, data centre electricity demand will grow by approximately three times its current level by the end of the decade, increasing from 3–4% of total electricity demand today to 11–12% in 2030 [6], with the same trend expected in the European Union. European data centre electricity consumption will reach almost 150 TWh by the end of the decade (62 TWh in 2023), representing approximately 5% of total electricity consumption (compared to approximately 2% today) [7].

In Russia, since 2017, Rosstat has singled out a direction in the balance of electricity - activities in the field of information technology and communications. Over the period 2017-2023, electricity consumption by this type of activity grew by 34% (annual rate of almost 5%), while in the country as a whole - by about 8% (annual rate of slightly more than 1%). In Russia, the future development of the communications and information technology sector is very uncertain. First of all, due to the lack of a clear policy in the field of cryptocurrency mining. Rapid development of data centers should be expected only after 2030, and then the growth rate of electricity consumption may approach that projected for Europe in the period up to 2030, while remaining lower than that projected for the United States (Fig.).

In the future, electricity consumption in the sector depends on the rate of economic growth, opportunities to improve the efficiency of data centers, as well as development trends in the field of artificial intelligence and cryptocurrency mining.



1 – based on the identified existing trend, 2 – taking into account global trends

Fig. Estimated uncertainty range of electricity consumption dynamics in the "information and communications" sector in Russia

The growth of energy consumption accompanies the development of any new technology. In the early stages, they are usually energy-intensive, but as they scale, they become more energy efficient. It seems that solutions will be found that will significantly reduce energy consumption in the sector.

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ONTOLOGICAL MODEL OF METHODS AND APPROACHES TO THE DEVELOPMENT OF DIGITAL TWINS

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Digital twin technology is of great interest to research groups and companies in the digital services market. This growing trend is confirmed by various reports on the state of the digital twins market, for example, in [1-2], as well as forecasts for the next few years [3].

The technology of digital twins has reached a level of development that allows it to be applied in practice. This facilitates the analysis of existing solutions, technologies, methods and approaches that have successfully proven themselves for solving specific tasks. The main trends in the field of digital twins include: technologies for streaming data from various Internet of Things devices for monitoring and forecasting tasks, 3D modeling, augmented and virtual reality, 3D visualization, various GenAI-based advisory systems, and more. Despite the growth trend, there are unresolved issues such as the lack of standardization between platforms and digital twin technologies, as well as difficulties in integrating solutions from different vendors, which affects the pace of technology adoption. Research in the field of modeling is underway in academicians, and numerical methods for developing models for specific applications in technological engineering are being discussed [4].

The report presents the results of an analysis of scientific publications, reports and projects on digital twin technologies in the energy sector and related areas. During the analysis, an ontological model was developed that combines tasks, methods, approaches and technologies related to digital twins in the energy sector. Based on the developed ontology, refinements are proposed to the digital platform architecture of the knowledge ecosystem in energy, which is being developed at the Melentiev Institute of Energy Systems.

Acknowledgements The work was carried out within the framework of a project under the state order of MESI SB RAS, topic number: FWEU-2021-0007, reg. no.:AAAA-A21-121012090007-7.

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SOFTWARE AND COMPUTING TOOLS FOR ANALYZING THE DYNAMICS OF SCIENTIFIC AND TECHNOLOGICAL TOPICS AS A COMPONENT OF THE KNOWLEDGE ECOSYSTEM

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Energy is one of the most important sectors of the global economy, determining the standard of living of the population and the economic development of countries. Modern challenges such as climate change, the depletion of natural resources and the growing demand for energy require the search for new solutions and technologies. Effective knowledge management and tracking the dynamics of scientific and technological processes are becoming key factors for sustainable energy development.

The knowledge ecosystem is a complex complex of interrelated elements that ensures the creation, accumulation, dissemination and application of knowledge. It unites various institutions, organizations, information resources and analytical tools that form the basis for innovative development. The most important component of this ecosystem is software and computing tools that allow for in-depth analysis and forecasting of trends in science and technology.

Analysis of the dynamics of scientific and technological topics plays an important role in understanding the evolution of scientific ideas and technological solutions. This process requires the use of modern methods and technologies such as bibliometrics, patent analysis, machine learning, and big data processing. The integration of these tools into the knowledge ecosystem helps to increase the accuracy of forecasting and prompt response to changes in the energy industry.

This article is devoted to the study of the role of software and computing tools in analyzing the dynamics of scientific and technological topics within the ecosystem of knowledge in the energy sector. The theoretical foundations of analytics, methodological approaches and practical examples of the use of modern technologies will be considered.

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MULTILEVEL MODELING OF CROPS PRODUCTIVITY IN ASSESSING THE FEATURES OF EXTREME YEARS

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In many works, the authors proposed to describe some time series of production and economic indicators by multi-level trends that reflect average, favorable and unfavorable conditions for obtaining agricultural products. Thanks to the trends of local minima and maxima, it is possible to identify favorable and unfavorable events, the probability of which is estimated using distribution laws.

Identification of favorable and unfavorable events can be used to assess the agrometeorological, hydrological conditions and anthropogenic factors of those years in which extreme events were formed. Such an assessment allows us to identify similarities and differences between favorable and unfavorable years. This can be used to forecast or scenario-based assessment of the results of the agricultural producer's activities.

Obviously, when solving the problem, large amounts of data are needed, since the consideration of series in the form of a hierarchical structure involves dividing the levels into three components: a sequence of local minima, maxima and intermediate values. In particular, for a series of wheat yields in Pakistan for 1952 - 2016 11 favorable and 15 unfavorable events were identified. In the USA, 20 favorable and 17 unfavorable events were selected for a similar indicator for the period 1932-2016. In Russia, according to data from 1942 to 2022, 23 favorable and 22 unfavorable events were found. Similar indicators for grain crop yields in the Irkutsk region were 21 favorable events and 16 unfavorable events according to information from 1950-2023.

For the selected years, which are characterized by the manifestation of favorable and unfavorable events, the annual precipitation and air temperature, similar indicators for the growing season and by months are analyzed. In addition, the intervals of the greatest influence of meteorological factors on the yield of agricultural crops are determined. The similarity and difference of the obtained intervals and the total values of precipitation and air temperature within them are analyzed. Using machine learning, years similar in the dynamics of factors and their interaction are determined, as well as their distinctive features to identify the prognostic capabilities of the obtained results. The presented algorithm for modeling extreme events is best applied to municipal districts and agro-landscape territories characterized by the homogeneity of the underlying surface and minor fluctuations in temperature and precipitation within their boundaries. It follows that the selected years of extreme events for large regions do not always coincide with the years of extreme events for municipal or agro-landscape districts. The coincidence of years when comparing the results of modeling for a region and its individual territories can be used to increase the information of one entity relative to another by using the analogy method when the volume of data is insufficient. The algorithm for identifying extreme years taking into account the hierarchy of time series of agricultural crop yields has been tested on data from the Irkutsk region and the Irkutsk district. It can be used both in the presence of multi-level trends and in their absence. In this case, the definition of unfavorable and favorable events is carried out based on averaged local minimums and maximums.

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SITUATIONAL AWARENESS FOR POWER SYSTEM OPERATION USING STATE ESTIMATOR

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Situational awareness (SA) is an understanding of the environment and the ability to predict how it may change under the influence of various factors [1]. The term SA was coined in an attempt to create a design of human decision-making processes in complex dynamic systems and is defined as the basis for all decisions and actions taken by people in the operation of complex and dynamic systems, including electric power systems (EPS).

In Russia, research on SA in the energy sector is conducted mainly in the field of nuclear energy and energy security, and interesting results have been obtained in research on cyber-security and cyber situational awareness of energy facilities at ESI SB RAS. [2] Due to low security awareness of end users, the constant need for reliable cyber-security solutions in the EPS is emphasized.

Reliable, fault-tolerant EPS operation requires real-time monitoring and management. Situational awareness of an EPS operator can be described as complete information about the current EPS state and all other facilities that may affect it. The complexity of power systems is constantly rised, it increases the risk that human operators will not be able to manage the network in any situation if their cognitive abilities are not supported by appropriate tools. The absence or insufficient level of the operator's SA significantly affects the likelihood that the system will enter a cascading power outage phase, and this transition is confirmed by numerous incidents in the power systems.

Expanding the SA capabilities of EPS operator means overcoming the cognitive barrier with the help of appropriate tools and visualizations. Such tools include the State Estimation (SE) procedure, which is the most important function that provides real-time calculation of the current EPS state. In this regard, in the last decade, research has been actively developing abroad on the application of SE methods to improve the SA of dispatchers of transmission and distribution networks of electric power plants [3].

State estimator is one of the key applications in energy management system (EMS). It serves as a vital module that validates the raw measurements from the supervisory control and data acquisition (SCADA) system and provides current system states for downstream applications in EMS. Among the disadvantages of the SCADA systems applied to gather measurements in power engineering are a low sample rate (one sample per 2–4 s) of SCADA data and lack of their time-synchronization. So the SE results may not be reliable and operators may lose the awareness of system condition in EMS.

The advent of next generation devices (PMU) for synchronized phasor measurements (voltage and current values in lines) makes it possible to realize linear algorithms of static and dynamic state estimation (LSE). Static SE uses PMU data for online monitoring of voltage values to detect bad data caused by errors or cyber attacks. Unlike static, dynamic SE tracks changes using pre-calibrated models of physical systems and time-synchronized measurements to evaluate immeasurable dynamic states.

ESI SB RAS developed a test equations method for detecting bad data in SCADA measurements and SE [4], which was then adapted to verify PMU measurements and implement LSE algorithms [5]. LSE algorithms allow you to get a solution within one iteration. The practical value of this approach lies in the simplicity of its implementation and the high speed of solving the problem. In [6], an integrated system of advanced LSE applications using PMU data

for SA is proposed. The system provides fast and guaranteed real-time SE at the PMU data transfer rate using a network model of a real power system. Data processing in all EMS modules uses the full resolution of PMU data and LSE results, and applications run fairly quickly with data transfer rates of up to 60 samples per second.

Modern EPS is cyber-physical system (CPS) in which cyber and physical subsystems influence each other. In [7], joint modeling of two subsystems, cybernetic and physical, is proposed to improve SA. Cybernetic modeling is typically event-based and finds applications in system testing, risk analysis, and staff training. Physical modeling focuses on power supply systems and requires tools and models representing stationary and dynamic processes. Cyber attacks on the CPS can target processes such as SE and feedback loops of FACTS devices. Due to cyber attacks on power systems, cascading accidents are spreading.

PMU deployment improves monitoring and situational awareness, eliminating cost and limited coverage issues requires system health assessment through interactions between cybernetic and physical subsystems to increase reliability and efficiency. The SE procedure using PMU data provides more reliable and accurate data for situational awareness over a wide area, real-time monitoring of dynamics, as well as analysis of events in the energy system.

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DEVELOPMENT OF COMPONENTS OF A SOFTWARE AND COMPUTATIONAL TOOLKIT OF DYNAMIC COGNITIVE MODELING FOR THE KNOWLEDGE ECOSYSTEM IN THE ENERGY SECTOR

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An overview of the application of dynamic cognitive maps is presented, aimed at assisting in the visualization and understanding of processes, as well as in decision-making under uncertainty in the energy sector [1]. The article also discusses the development of the DCM Creator toolkit, which is designed to simplify the creation of dynamic cognitive maps (DCM), and compares its functionalities with existing solutions, using Insight Marker as an example [2]. Additionally, emphasis is placed on the application of graph neural networks (GNN) to enhance DCM. GNNs allow for the efficient processing and analysis of data obtained from DCM, opening new horizons for their application in the forecasting and optimization of energy systems [3]. The results of the study can be utilized for further development of the software-computational tools for dynamic cognitive modeling, as well as for improving the approach to analyzing various factors that influence the development of the energy sector as a whole.

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SUBJECTIVE ASSESSMENT BY LABORATORY STAFF OF THE MEDICAL INFORMATION SYSTEM AT THE STAGE OF ITS IMPLEMENTATION

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Information technologies have long been widely used in the activities of medical institutions. It has become common to use them for reporting, communication and information exchange, accounting of material assets, financial settlements, patient appointments with a doctor, as well as in diagnostic devices and laboratory analyzers. A feature of the already achieved level of informatization is the "patchwork" of the information field. This creates difficulties in the analysis of integrated data, complicates situational management in critical situations. At present, the digital transformation strategy approved in our country covers all levels of healthcare with implementation deadlines in 2024 - 2030 [1]. In accordance with this strategy, improving the information support of medicine and organizing interdepartmental electronic interaction should increase management efficiency and improve the quality of medical care to the population.

Modern management standards contain requirements for monitoring the risks of exposure to unfavorable factors. Accounting and verification of these factors allows us to identify and assess the possibility of a dangerous situation, carry out timely development and adoption of measures aimed at reducing the likelihood of harm and reducing its severity to an acceptable level [2].

In the Irkutsk region, the creation of a single digital circuit in healthcare based on a single state information system continues. The Regional Medical Information System (MIS) is being formed, and the Unified Digital Platform (UDP) is being introduced into all medical institutions in our region. The creation of a single information space in healthcare and the digitalization of activities involves covering all sections of medical care and departments of medical organizations. An integral and closely integrated part of the MIS of a medical institution is the laboratory information system (LIS) [3]. Accordingly, the success of the implementation and use of the MIS in the hospital as a whole will depend on the stability of its functioning The transition to new software, and especially the introduction of information technologies into technological processes will always be accompanied by a number of difficulties, the overcoming of which will determine the speed and efficiency of digitalization. The purpose of the work was to facilitate the development of the new MIS by employees of medical organizations of the Irkutsk region. For this, the following tasks were solved:

- Assess the interest of doctors in the implementation of the new version of the Medical Information System.
- Identify the difficulties characteristic of specific medical institutions in the digitalization of the patient record.
- Focus the attention of the management on the existing problems with the implementation of information technologies in a specific hospital.
- Submit reasonable proposals to the administration of medical institutions designed to facilitate the transition of doctors to the new MIS.

In order to be able to judge the process of digitalization of the region as a whole based on the results of the analysis, medical institutions were selected that differ significantly from each other. At the first stage, they included a large hospital located in the regional center, a city clinic,

and a hospital in one of the districts of the Irkutsk region. To collect the opinions of doctors on the implemented MIS, Questionnaires were created using Yandex tables. One of the questionnaires contained information about the medical organization where the survey was conducted, and the other contained questions characterizing the processes of interaction between the registry, treatment rooms and hospital departments, laboratories and clinicians. The survey results were processed and reported to the management of medical institutions.

The analysis of the opinions of doctors on the implemented information system made it possible to identify features characteristic of specific medical institutions. Among them, it is necessary to highlight the shortcomings characterizing material factors, such as low bandwidth of the Internet network through which the equipment of the departments is connected; insufficient performance of computers at workplaces. The characteristics of the management process include the involvement of management and specialists responsible for the implementation of the information system in the training of doctors; the position of the administration on the assessment of "human potential"; the interest of employees in digitalization and improvement of the technological process. A separate group can include constructive proposals aimed at improving the (UDP) as a whole or at fine-tuning the IS taking into account the specifics of a particular organization.

In addition to identifying production problems, the analysis of questionnaires allows identifying and possibly appointing to management positions those specialists who are most interested in mastering new technologies, increasing labor productivity, and reducing the number of errors made.

Taking into account errors and failures allows not only to focus attention on problem areas, it provides an opportunity to move from eliminating failures that have already occurred to predicting possible deviations and risk management. There is no doubt that the effectiveness of patient treatment is largely determined by the use of all the possibilities of information technology. Their use in medicine allows optimizing approaches to both diagnostics and treatment, as well as to managing production processes in healthcare.

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ADAPTATION OF ICS WICS TO STUDY OF THE RESILIENCE OF ENERGY AND SOCIO-ECOLOGICAL SYSTEMS

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Currently, the Department of Artificial Intelligence Systems in Energy is developing a Digital Platform of the knowledge ecosystem in energy. It includes the following main blocks:

- "resources" – includes knowledge and knowledge representation models, mathematical models and data; data, in turn, is divided into structured data (described by data models), unstructured and semi-structured data (which are stored in "Data Lake"), streaming data and datasets (intended for processing by neural networks);
- "processes" – includes three groups of processes: processes with resources, user processes and service processes;
- "services" – includes three main groups: services, responsible for storage of data and knowledge (Knowledge Warehouse, Data Lake)), services of mathematical and semantic modelling and basic components of digital twins, services of data and knowledge generation.

In more detail Digital Platform is discussed in the report by L.V. Massel "Digital Platform of Knowledge Ecosystem in Energy", architecture of the platform is presented in Fig. 1.

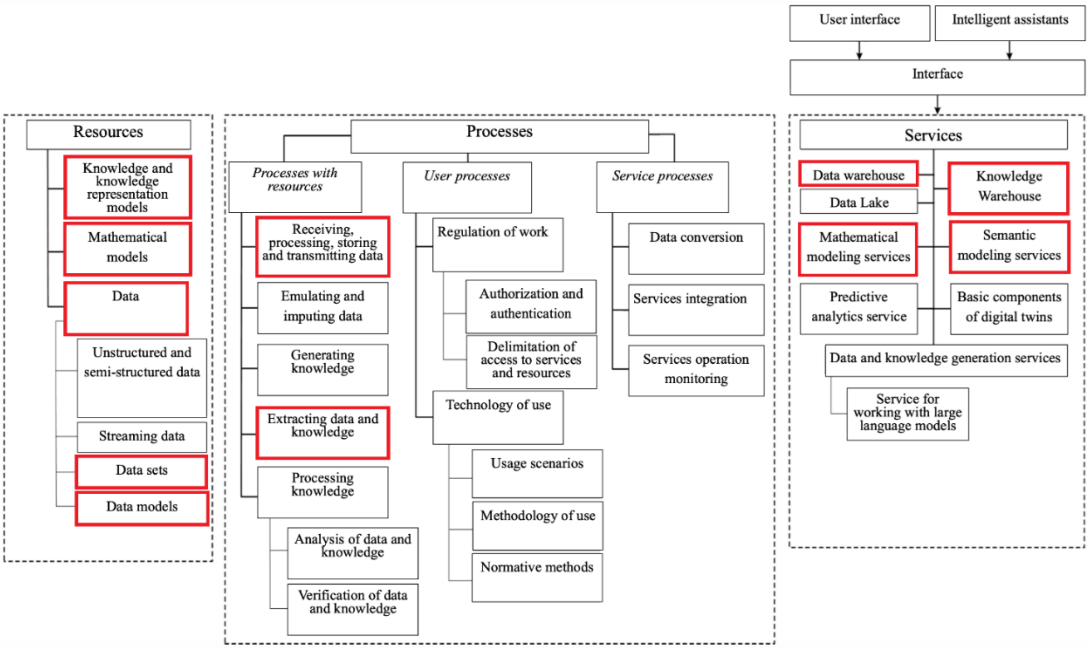

Fig. 1. Architecture of the digital platform of the knowledge ecosystem in energy

One of the areas of application of the Digital Platform being developed is research into the sustainability of energy and socio-ecological systems. The information and computing system (ICS) WICS can be used as a tool for these studies. The report examines the ICS WICS and its main components. It is shown that the ICS WICS can be used within the Digital Platform as part of (highlighted in red in Fig. 1):

- resources – mathematical models for calculating emissions of pollutants and their dispersion in the atmospheric air, results of the calculations can be used as data for other

calculations; also ICS WICS can provide data models, for example, of an energy facility; the WebOntoMap component for working with ontologies built into the ICS WICS system can provide knowledge and knowledge representation models (ontology models);

- processes – ICS WICS can be used as part of the following processes: 1) receiving, processing, storage and transmission of data; 2) data extraction;
- services – ICS WICS can be part of the following services: mathematical and semantic modeling services, data warehouse and knowledge warehouse.

The report also describes what improvements will need to be made to provide the integration of the ICS WICS and Digital Platform.

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ADVANTAGES OF USING THE ECOSYSTEM OF KNOWLEDGE IN THE ENERGY SECTOR

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Recently, due to the rapid development of digital technologies, new paradigms of working with knowledge have emerged. The amount of knowledge that each person has to work with has increased significantly. Today, people are trying not just to manage knowledge, but to create entire "ecosystems" around it [1].

This concept was introduced by biologists in the 1930s, but has recently been used as a metaphor and often appears in the literature on industrial marketing. Today, the terms "ecosystem" and "knowledge" have merged into one and represent a new approach to implementing meaningful knowledge management. The foundations of this approach are aimed at developing interaction between exchange participants, simplifying decision-making and promoting innovation through the development of cooperation between participants. Given the continuous development of the digital economy in the Russian Federation and the main directions of the implementation of the digital agenda, we can safely say that the knowledge ecosystem should be a "digital platform of the knowledge ecosystem" [2].

Ecosystem participants, performing certain roles, are embedded in the general chain of knowledge creation, and the ecosystem itself is a digital platform connecting various actors through information and communication technologies and ensuring satisfaction of wide consumer demand for various knowledge resources of this ecosystem. Having a well-established ecosystem increases the trustworthiness of customers, and consequently increases their loyalty level, which in turn ensures the stability and success of the organization, in our case, an organization for the transfer, production and improvement of knowledge. Having an ecosystem, a scientific organization gets a number of advantages, such as [3]:

1. The speed of engagement. A researcher, as a user of the ecosystem, is more quickly involved in relevant results in the field of his interest.

2. Increase loyalty. A researcher is aware of the convenience of the ecosystem, shares current results (transmits knowledge), and helps maintain an assessment of the level of knowledge (the state of the field in the ecosystem).

3. Reducing time costs. The speed of knowledge transfer between scientific departments increases due to simultaneous interaction between employees. (not a person with a person, but all possible options for interaction, a person with a group, a group with a group).

4. Improving the quality of working with knowledge. Within the framework of the digital platform, a web application of the knowledge ecosystem can be presented, in which transitions between the most important sections will be carried out.

5. Increased efficiency. In the case of scientific activity, the web application will present: assessment of the current knowledge of the ecosystem using current methods of mapping informal knowledge in the field of energy, visualization of current areas of research and development in the field of energy and forecasting new research.

Loyalty is one of the main advantages of the ecosystem. Let's look at the advantages of increasing loyalty using the example of a knowledge ecosystem:

1. Simplicity and ease of use, as many services and services within the ecosystem are combined in a single application with a seamless transition.

2. The ability to meet the diverse needs of users due to the availability of a wide range of functionality.

3. Personalization, facilitating the use of services in accordance with the individual needs and interests of users.

The ecosystem currently being created will provide new opportunities to meet needs and serve as an effective tool for improving knowledge management. Both the result and the value creation process are very important to people. Ecosystems allow us to meet the many needs and interests of a wide range of people, simplifying interactions with them, which, in turn, contributes to an increase in successful scientific discoveries.

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ANALYSIS OF DATABASE INTEGRATION CHALLENGES IN AIR TRANSPORT: TECHNOLOGICAL AND METHODOLOGICAL ASPECTS

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This project addresses the challenges and solutions related to merging databases with different dimensions in the field of airways transport. The focus is on the technical and methodological aspects of data integration, including format incompatibility, data transformation, normalization, and standardization. The application of ETL processes, integration platforms, and OLAP cubes facilitates effective data management, ensuring consistency and relevance. Examples of OLAP analysis for data integration are demonstrating improvements in analytical capabilities, route optimization, and service quality enhancement. The application of these methods contributes to more informed managerial decisions and increased efficiency in business processes within the aviation industry.

DEVELOPMENT OF THE WEB VERSION OF «INTEC-A» AS A COMPONENT OF THE DIGITAL PLATFORM OF THE KNOWLEDGE ECOSYSTEM IN THE ENERGY SECTOR

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The digital platform for knowledge ecosystem includes computer, mathematical models, databases and knowledge, information and intellectual subsystems, visualization subsystem and necessary services.

The MESI SB RAS has developed a program complex (SP) Web “INTEC-A” for research of fuel and energy complex (FEC) development directions. The SP is assigned for searching the optimal way of fuel and energy complex development. Web version of “INTEC-A” is obtained as a result of re-engineering of previous versions of the PC. It implements web-services for mathematical modeling of the state of the country's fuel and energy complex and search for an optimal solution. Also services for filling data storages, realizing data input, processing and retrieval are implemented. MYSQL DBMS is used. The database stores data required for building a technical and economic model of the fuel and energy complex and data on the impact of threats and measures on the development of the fuel and energy complex. A cognitive modeling service is under development, which allows using a cognitive map to set scenarios of fuel and energy complex development.

Web “INTEC-A” is based on the technical and economic model of the fuel and energy complex developed by the Energy Security Department No. 30 of MESI SB RAS. Using this model, the problem of minimizing the sum of damages and underdeliveries of fuel and energy resources to the end consumer is solved.

THE USE OF LARGE LANGUAGE MODELS TO BUILD FORMALIZED ONTOLOGICAL MODELS

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When developing an ontology portal, one important issue is its content. As part of the project, we proposed using generative AI - large language models (LLM) - to generate fragments of ontologies in OWL/RDF.

Traditional methods based on statistical analysis and mathematical modeling often encounter problems with insufficient accuracy and outdated data. The Artificial Intelligence Department for Energy Systems at ISEM SB RAS works on creating an ontological knowledge portal. Its main objectives are to establish a common terminology base and use an ontology system to build semantic models for intellectual decision-making in energy research in the future. All this aims to solve the aforementioned problem.

When developing ontologies, the "bottleneck" is the formation and filling of a finished ontology. Moreover, the process requires the participation of two specialists: a cognitive engineer and a domain expert, making the process doubly complicated for filling an ontological portal. Two approaches are used to create the ontological space: processing declarative knowledge and formalization, as well as adapting already constructed ontologies. To solve the first problem, GigaChat was used to generate RDF triples, from which an ontology can be formed. The second approach is to create an OWL-like ontology using Mistral, which allows you to add information to the OWL file or combine several separate ontologies using graphical ontologies created in CmapTools.

The only thing is that, after the formation of ontologies in the OWL format, it is necessary to slightly refine their overall structure, since there are problems with the allocation of classes and subclasses.

DIGITAL PLATFORM OF KNOWLEDGE ECOSYSTEM IN ENERGY

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Two years ago, the staff of the department «System of artificial intelligence in energy» proposed the development of an ecosystem of knowledge in energy, as an innovative approach to managing knowledge [1]. It was proposed to use, as the basis of the development, the architecture of IT-infrastructure of system studies in energy, developed by the department [2]. This year, it is proposed, based on [3, 4], to modify this architecture and consider it as a digital platform architecture.

Under the digital platform (DP) we mean a system of tools that supports the use of digital processes, resources and services by a significant number of subjects of the digital ecosystem and provides the opportunity for their «seamless» interaction. Otherwise, the concept of DP for the ecosystem of knowledge includes not only computer and mathematical models, but also databases and knowledge bases, informational and intelligent subsystems, visualization subsystems and necessary services. Based on the above definition, it is proposed to identify the following types of resources, services and processes.

Resources (on the left in the figure) include knowledge and knowledge representation models, mathematical models and data, which in turn are divided into structured data described by data models, unstructured and semi-structured (data lakes are used to store them), streaming data and datasets (intended for processing by neural networks).

The Processes block (in the center of the figure) includes three groups of processes: processes with resources; user processes; service processes.

1. Processes with resources include: (1) receiving, processing, storing and transmitting data; (2) emulating and imputing data for the digital twins; (3) generating knowledge; (4) extracting data and knowledge; (5) processing data and knowledge. The latter includes: (5.1) analysis and (5.2.) verification of data and knowledge.

2. User processes include (1) regulation of work, which highlights (1.1) authorization and authentication and (1.2) delimitation of access to services and resources, and (2) technology of use, based on (2.1) usage scenarios, supporting (2.2) methodology of use and including (2.3) normative methods.

3. Service processes include (1) data conversion; (2) services integration; (3) services operation monitoring.

Services (in the figure on the right) are defined by the interface type (a regular user interface or an intelligent assistants using large language models), and include the following 3 service groups.

Group 1: Data warehouse (DW) (for storing structured data); Data Lake – for storing unstructured or semi-structured data; mathematical modeling services using data from the DW; predictive analytics service using all types of data.

Group 2: Knowledge Warehouse, Ontological Portal, semantic modeling services and basic components of digital twins.

Group 3: Data and knowledge generation services, including a service for working with large language models.

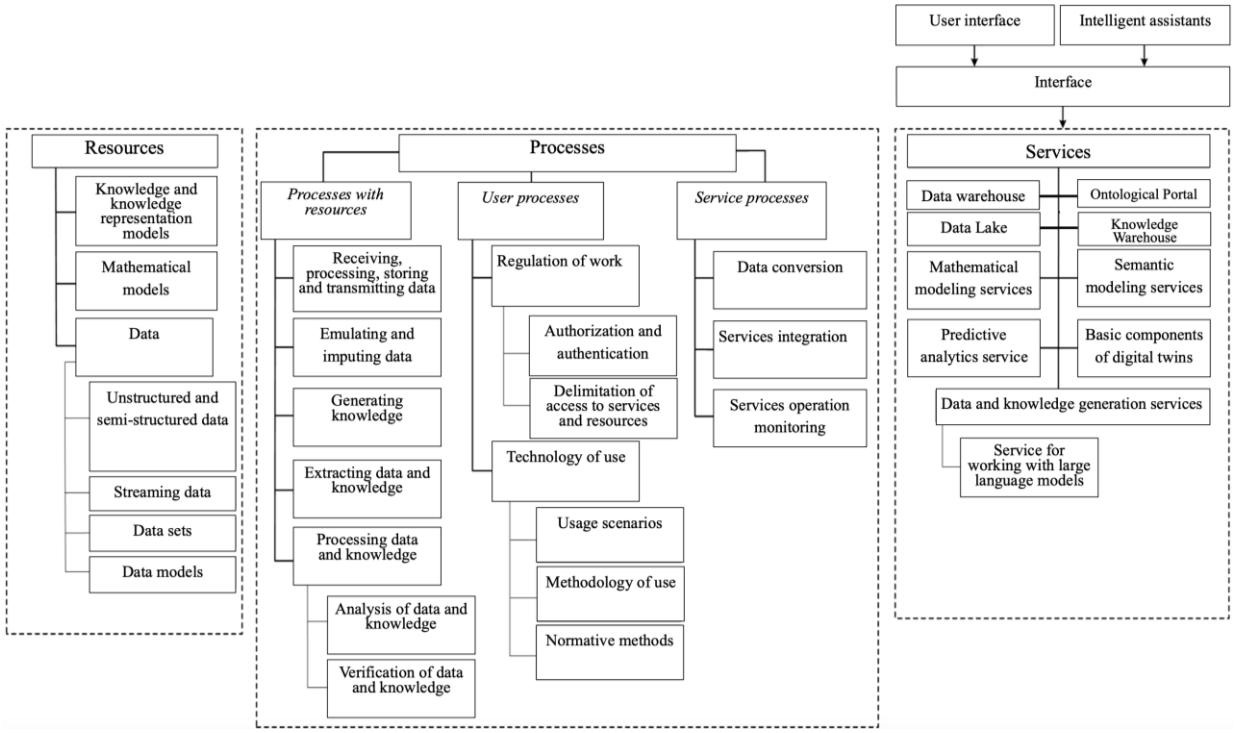

Fig. 1. Digital platform architecture of the knowledge ecosystem in energy

Currently, work is underway to inventory existing resources, adapt scientific prototypes services and tools developed in the department, and design missing services. It is expected that this architecture will be further discussed, supplemented and refined.

Acknowledgements. The work was carried out within the framework of a project under the state order of MESI SB RAS, topic number: FWEU-2021-0007, reg. no.:AAAA-A21-121012090007-7.

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APPROACHES FOR MODELING AND ANALYZING SCIENTIFIC KNOWLEDGE FLOWS WITHIN KNOWLEDGE ECOSYSTEM IN ENERGY SYSTEM

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In the rapidly evolving field of energy research, the efficient management and analysis of scientific knowledge are crucial for driving innovation and fostering collaboration. The increasing volume and complexity of scientific information require advanced methods for modeling and analyzing scientific and technology knowledge flows within the energy knowledge ecosystem [1].

This study explores a range of methodologies for capturing, structuring, and interpreting the dynamics of scientific knowledge exchange in the energy sector. Network analysis can be applied to identify key knowledge hubs, collaboration patterns, and influential research domains. Bibliometric analysis is used to track citation networks, emerging research trends, and interdisciplinary interactions. Additionally, machine learning techniques such as topic modeling and natural language processing (NLP), oriented large language models (LLM) are utilized to uncover latent relationships and forecast future developments in energy research and development [2, 3].

By integrating these approaches, we aim to enhance the accessibility and strategic use of scientific knowledge, supporting data-driven decision-making in academia, industry, and policy-making. The proposed methodological framework contributes to the development of intelligent knowledge management platforms that facilitate innovation, accelerate the adoption of cutting-edge technologies, and strengthen scientific cooperation in energy sector [4]. This research highlights the importance of systematic knowledge modeling in shaping a more adaptive and resilient knowledge ecosystem for energy system research. The findings offer valuable insights for stakeholders in academia, industry, and government, aiming to optimize knowledge flow and improve research impact.

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PRINCIPLES OF ORGANIZING AN ONTOLOGICAL KNOWLEDGE PORTAL WITHIN THE FRAMEWORK OF A DIGITAL PLATFORM OF KNOWLEDGE ECOSYSTEM

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The Ontological portal of knowledge in the field of energy is one of the components of the Digital Platform of the knowledge ecosystem. The basis of the ontological portal is a set of ontologies in the field of systemic research in energy sector. In the architecture of the Digital Platform, ontologies are Resources, or more specifically, Knowledge [1]. The Ontological portal is used as a service that provides access to knowledge (ontologies), or more specifically, the presentation of knowledge to the user. It is planned to implement inference rules on ontologies, with their help, within the framework of the Ontological portal, knowledge generation and its presentation to the portal user will be performed.

To use ontologies in the Ontological portal, they must be developed in the universal ontology description language OWL, which will ensure automation of their processing (filling, expansion, output). The Department of artificial intelligence systems in energy sector of the ESI SB RAS has a large number of disparate lightweight (empirical) ontologies developed in the CMap Tools. This complicates the design and development of the Ontological portal for two reasons. The first is that the disparity of ontologies complicates the development of a structure for integrating all ontologies into a unified complex. It is necessary to take into account many features of various subject areas, as well as many points of view on systemic research in energy sector, and build a structure in such a way that it meets the requirements of as many subject area specialists as possible. The second reason is that ontologies in the CMap Tools format are visual graph models of lightweight ontologies. While ontologies in the OWL language are “heavyweight” ontologies that are described in a formalized language. There are specific descriptions of classes, dependencies, data types, etc. Therefore, a strict and complete specification of all ontology objects is required.

A partial solution to the first problem is a step-by-step design of the subject area. It is proposed to start the design by identifying energy research areas by industry: thermal power engineering, nuclear power engineering, hydropower engineering, wind power engineering, solar power engineering, geothermal power engineering. In this case, the level of detail down to individual energy objects is assumed. To automate the implementation of this solution in the future, as well as to facilitate the construction of ontologies in the OWL language, it is proposed to use Ontology Design Patterns [2].

According to [2], there are 6 types of ontological design patterns: Structural, Correspondence, Content, Reasoning, Presentation, and Lexico-Syntactic. When designing and implementing an ontological portal, we are interested in Structural patterns, Presentation patterns, and Content patterns.

Particular attention is paid to the use of Content patterns. They are used to describe the methods of representing typical fragments of ontologies, so that they can be used to construct subject area ontologies. When developing Content patterns, so-called qualification questions are used, which help to identify the main interaction options of the logical blocks being described.

Using qualification questions and attributes characterizing entities, the following Content patterns have already been developed: Subject Area, Research Object, Research Subject, Research Method, Project, Publication. In this work, it is possible to use the "Subject Area"

pattern without changes (Fig. 1). However, the structure of the pattern may change after the approval of the structure of the ontology complex.

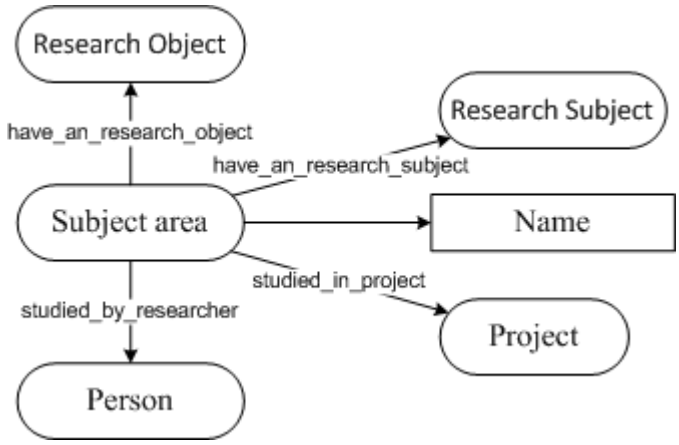

Fig. 1. Content pattern "Subject Area"

Conclusions. When designing and developing an ontological knowledge portal in the field of energy, the following principles must be observed:

1. Using a strictly structured set of ontologies
2. Using Ontology Design Patterns
3. Using the OWL language for developing ontologies

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METHODOLOGICAL FEATURES OF THE THREATS IMPACT STUDY ON THE RELIABILITY OF ENERGY SUPPLY IN MODERN CONDITIONS

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The relevance of studying threats to energy security in the new conditions of energy systems operation is increasing and imposes new requirements on modeling tools for conducting research on the analysis of the threats impact to the normal functioning and development of energy sectors and ensuring reliable energy supply to consumers.

The initial basis for conducting research is the characteristics of possible threats that can be re-alized in the form of emergency situations in the fuel and energy complex and energy sector indus-tries, technical and economic characteristics of energy facilities and reporting data on the state of energy systems, the results of options studies for the development of energy systems and the fuel and energy complex.

Based on the above characteristics and threat analysis, the calculated conditions for the com-putational experiment are forming, which is carried out using a model for optimizing the develop-ment of the fuel and energy complex, taking into account the energy security factor when assessing the impact of a particular threat on the reliability of energy supply to consumers.

The developed version of the model takes into account the following changes (Fig.):

- changes in the directions of fuel and energy resources export flows (gas, oil, oil products, coal, electricity);
- changes in territorial fuel and energy balances taking into account the gasification of the country's regions;
- intensive development of Siberia and the Far East the energy systems;
- the electric and thermal energy block is supplemented and modified taking into account the revised draft of the General Scheme (General Scheme) for the placement of electric power facilities until 2042.
- improvement of the model financial block taking into account the above changes: introduction of investment indicators (variables) for the reconstruction, modernization of existing capacities, decommissioning of obsolete equipment, introduction of new capacities at energy industry facilities. Additional equations are introduced into the model that describe specific capital investments per unit of new capacity for all technological stages.

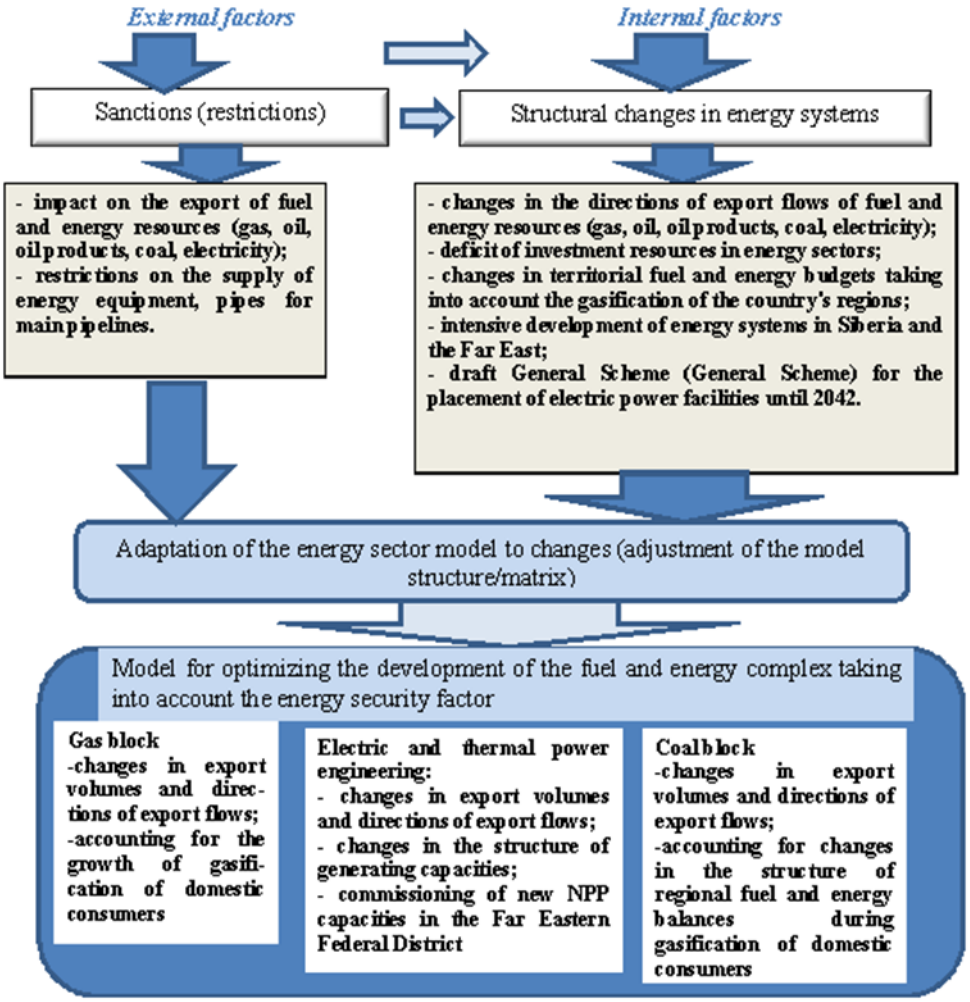

Fig. Scheme of transformation of the model of optimization of development of the fuel and energy complex for research of reliability of fuel and energy supply of consumers in modern conditions

Improvement, modification and debugging of the model is carried out on the updated modi-fied software package "INTEK-A" (simultaneously with its debugging). The web version of the PC "INTEK-A" is designed to support decision-making in predictive studies of the fuel and energy complex, taking into account energy security requirements. Calculations are performed using the solver of linear optimization models. The PC allows you to model technological and territorial con-nections of the fuel and energy complex, the implementation of threats to the fuel and energy com-plex development and measures to prevent or eliminate the consequences of the implementation of threats to the development of the fuel and energy complex. The sequence of work with the model and the INTEK-A software package is carried out according to a certain scheme.

To check the adequacy and correctness of the software and model improvements (adjust-ments), a test experimental calculation was carried out to assess the impact of a decrease in the gen-eration of Siberian hydroelectric power plants on the reliable energy supply to consumers.

VISUALIZATION COMPONENT AS ONE OF THE BASIC COMPONENTS OF THE DIGITAL TWIN IN THE DIGITAL PLATFORM OF THE KNOWLEDGE ECOSYSTEM

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The digital platform provides "seamless" interaction between subjects, which is fundamental for the effective functioning of digital twins. A digital twin is a virtual prototype of a real system used to analyze, optimize, and predict the behavior of objects or processes [1, 2]. In this context, the visualization component plays a key role, allowing complex data to be transformed into visual and accessible formats that improve understanding and analysis.

Visualization provides interactive capabilities, allowing users to manipulate data and explore different scenarios in real time, which facilitates more informed decisions. Effective visualization requires integration with databases and analytical tools to ensure the accuracy and relevance of the data presented in the digital platform. It must support multi-user interaction, facilitating collaboration and knowledge sharing across the ecosystem.

In addition, the visualization should be user-friendly and aesthetically pleasing, increasing user engagement. Innovative technologies such as virtual and augmented reality (VR/AR) open new horizons for interacting with data and improving visualizations. The application of the visualization component in practice can be seen in various sectors such as industry, healthcare, and education, highlighting its versatility and importance. To conclude, it is worth noting that the application of visualization in digital twins and knowledge ecosystems will open up new opportunities for data analysis and management [3].

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APPROACHES TO MODELING THE IRKUSTSK REGION POWER SYSTEM IN THE STUDY OF ENERGY SECURITY

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Modeling of large-scale power systems is associated with a number of difficulties, mainly depending on the large number of elements of such systems [1]. In this regard, the choice of modeling approach and the type of mathematical models used in it is the key in building models of large-scale systems.

Determining the necessary level of aggregation and detail of the system elements directly affects the accuracy of calculations and the speed of calculations: too high aggregation makes the calculation results inaccurate, which reduces their relevance; increasing the detail on the contrary increases the accuracy, but significantly reduces the speed of calculations, up to the impossibility of their execution due to the lack of required computing power.

This paper briefly describes the approach to mathematical modeling of large-scale power systems (with a focus on thermal power plants) in the study of power supply reliability and energy security. Further, the paper presents the peculiarities of the Irkutsk power system and their influence on the choice of modeling approach.

This paper compares different model variants of the Irkutsk Oblast power system in terms of aggregation and detailing and determines the optimal scheme for further research.

The paper also provides modeling scenarios for the computational experiment, each of which will simulate different conditions, such as a sharp increase in winter energy consumption, failure of a large generator, or changes in electricity tariffs. For each scenario, the possible consequences will be analyzed and their impact on the stability of the power system will be assessed to identify potential risks and vulnerability points.

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APPLICATION OF SWARM INTELLIGENCE ALGORITHMS TO SOLVE THE DISCRETE PROBLEM OF ATOMIC-MOLECULAR MODELING USING THE MORSE POTENTIAL

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Currently, interest in the problem of obtaining ultrafine dispersed structures of atomic-molecular clusters continues to grow. The goal of such studies is to find a cluster structure with minimal potential energy [1]. Many problems of searching for low-potential states of atomic-molecular clusters consist in minimization of non-convex functions and are characterized by an extremely fast increase in the number of local extrema with increasing number of variables. The problem of finding a global optimum of a multi-extremal target function remains one of the most complex and relevant in optimization theory and applications. The paper considers the problem of discrete minimization of the Morse potential [2], which is an integer multimodal function.

Research on the creation of numerical methods for nonlocal optimization has been quite active in recent years. Nowadays, specialists have proposed a significant number of search algorithms of various types, each of which has its own computational characteristics. One of such algorithms are metaheuristics “inspired by nature”, including swarm intelligence algorithms [3, 4], the growth of their popularity is associated with the increase in computing power and the need to solve large-scale optimization problems.

As swarm intelligence algorithms for optimizing the Morse potential, this paper used “particle swarm”, “gray wolf pack”, “student group”, “firefly swarm” and “bee colony” methods [3, 4]. These algorithms were investigated on atomic-molecular clusters of dimensions from 5 to 50 atoms. The computations performed by each of the five swarm intelligence algorithms were compared. The results of numerical experiments confirming the performance of the applied algorithms are given.

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APPLYING MACHINE LEARNING METHODS TO PROCESS DATA FROM A DIGITAL KNOWLEDGE ECOSYSTEM PLATFORM

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The digital platform for the knowledge ecosystem contains important resources such as data and the corresponding processes that are performed with it: data extraction, processing, storage, emulation and imputation. There are various machine learning techniques available for this task. The main feature of which is data-driven problem solving.

The primary problem may be the format for obtaining data for further processing. The options for storing data in a digital platform are of two main types: structured, located in databases usually represented as tables, or unstructured (data lake), which can come in various forms (readings from IoT equipment or text documents). To solve this problem, analyses are needed to identify methods and tools to process the data. Based on the data format, the methods for processing can be different: data mining, natural language processing and text mining.

The processing of structured data already has specific tasks. In the basic components of the digital twin, data prediction tools (recurrent neural networks or bousting methods) and state classification and outlier finding (deep learning, classical learning methods) can be presented as a service. To specify the method, it is necessary to identify the number and dimensionality of the data, as well as an estimate of the accuracy of the model in the form of metric indicators (different for each task).

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MODELING OF AN INDIVIDUAL INDICATOR OF THE ACTIVITY OF RESEARCHERS

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In the modern world, scientific research plays a key role in the development of society, economy and technology. The effectiveness of scientific activity directly depends on the productivity and quality of work of scientific staff.

Assessing scientific productivity is a complex task that requires taking into account many factors [1], such as the number and quality of publications, participation in grant projects, teaching and mentoring activities, patents and innovations, as well as participation in scientific events. The issue of assessing the effectiveness of an employee is of interest to any employer. And if commercial organizations have long introduced key performance indicators (KPI - key performance indicators) [2], then there are still problems in assessing the scientific team. Despite the fact that most scientific organizations introduce "indicators of scientific activity" to solve the problems of assessing a scientific worker, and in universities - effective contracts, the problem of assessing scientific teams and individual scientific employees is still considered not fully resolved.

Modeling an individual performance indicator allows for an objective assessment of each employee's contribution to scientific activity, which contributes to a more rational distribution of resources, improved research quality and stimulation of professional growth.

To calculate an individual performance indicator for research workers, it is necessary to create a table of initial data, in which the indicators are divided into 3 groups: scientific, organizational and technical.

The indicator value is determined by experts in accordance with a point scale:

1) the head of a department/division/laboratory independently assigns points depending on the employee's work;

2) a group of 3-4 people, including the manager;

3) some indicators are calculated automatically, according to the specified parameters.

The indicator weight is determined based on various employee characteristics, as well as the area of scientific research:

1) the employee's area of activity;

2) age, length of scientific work experience, postgraduate studies, etc.

The group weight is determined based on the position held.

These tables are filled in for each employee in order to calculate the individual performance indicator for the research worker.

After entering the data on the employee, the individual performance indicator of scientific workers is calculated according to the formula (1):

$$IPI = \sum_{i=1}^{n} W_i (\sum_{j=1}^{m} W_{ij} B_{ij}) \quad (1)$$

where:

IPI – individual performance indicator of scientific workers;

W_i – weight of the group of indicators;

W_{ij} – weight of the indicator;

B_{ij} – value of the indicator.

Due to the complexity of formalizing all the indicators that should be taken into account when calculating the indicators of individual scientific activity of researchers, and given that the

authors propose to take into account not only the scientific staff, which according to the regulations includes only research staff, but also the engineering staff of the team, it is proposed to use ontological engineering of the subject area [3].

It is proposed to divide the ontological space into three groups: ontologies of indicators, ontology of weights, ontology of assessed employees.

When developing specific ontologies, projects that are being carried out in the Department of Artificial Intelligence Systems of the Institute of Economics and Management of the Siberian Branch of the Russian Academy of Sciences were analyzed. The main part of the tasks was analyzed from the project management system, and then divided into three categories.

At the first stage, a system of "light" ontologies is built, with the help of which it is possible to coordinate with the heads of structural divisions the necessary parameters that should be included in the calculation of indicators.

The second stage is the transition to strictly formalized ontologies, their description in the RDF language for verification and checking for contradictions.

The use of an individual indicator of the activity of scientific workers will allow ranking employees according to the degree of their involvement and scientific and organizational types of activity of the department/division, and also determining, on this basis, the amount of incentive payments.

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EVALUATION OF EFFICIENCY OF HYBRID SYSTEMS WITH SOLAR PANELS BASED ON QUEUING THEORY

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Renewable energy is becoming increasingly important in the modern world. The escalating global demand for energy, coupled with climate change and the depletion of fossil fuel reserves, are reasons for renewable energy sources development. However, the impermanent nature of most renewable energy sources, particularly solar and wind power, presents significant challenges to grid stability and reliability. While renewable energy technologies have become more efficient in recent years (wind and solar market share grew to 8.5% of worldwide electricity in 2019 [1]), the variability of weather conditions, influenced by diurnal cycles, seasonal changes, and less power capacity compared traditional energy make it impossible to completely abandon traditional energy. There are only a few cases of usage pure solar or wind energy in Russian regions even for daily living needs, not to mention industrial needs. In this way, hybrid energy systems are the solution for making today energy system more sustainable. Hybrid energy systems combine two or more energy generation technologies, often including renewable sources and a permanent one (e.g. solar panels and city grid). By strategically integrating complementary energy sources, hybrid energy systems improve system reliability and optimize energy efficiency.

For estimating efficiency of applying solar power system, usually it is used an economic approach (i.e. an investment analysis). It considers the technical characteristics and economic indicators (such inflation) but does not consider the stochastic nature of weather conditions [2,3].

In this study, queuing theory as an approach of theory of stochastic process is applied for evaluation of efficiency of hybrid energy systems. We propose a mathematical model for an object powered by the city electric grid and its own solar panels in the form of a queuing system with two service units. We suppose that the first service unit describes a source of permanent energy (city electric grid), and the second one defines a renewable source, e.g. solar panels. In the model one service unit is stable and unlimited, other one is limited and stochastic ("unreliable" in terms of queuing theory). Consumers prioritize using alternative energy, that means customers in the queueing model choose the second service unit if it is possible. When the accumulated solar energy runs out, city electrical grid begins to consume (only the first service unit works). Two cases of a consumer strategy are considered: usage of solar energy for individual non-urgent targets and both types of energy mixed in one grid by special equipments (e.g. smart meter). In this way the models with switching and with delayed service are considered. Based on queuing theory, the main characteristics of the system are derived, the form of cost function is proposed, and efficiency of hybrid systems are evaluated. By numerical comparison of two model cases and classical queueing model $M/M/\infty$, the conclusion about optimal consumer strategy in the given initial conditions can be made.

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A PLATFORM FOR THE DEVELOPMENT OF INTELLIGENT PERSONALIZED MEDICAL INFORMATION SYSTEMS

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Personalized medicine is the provision of comprehensive medical care, carried out in accordance with the characteristics of a particular patient. Existing medical information systems are often unable to adequately take into account the individual characteristics of patients, such as genetic data, personal medical history, lifestyle, current health indicators, and other factors. This leads to insufficient personalization of medical care, which can reduce the effectiveness of treatment and lead to erroneous results.

Therefore, the objective is to create a platform for the development of intelligent personalized medical information systems. The functional core of this platform will allow creating systems capable of recording individual patient parameters, monitoring health indicators, and using machine learning methods to provide personal recommendations and more accurate diagnoses. To achieve this goal, existing solutions and tools have been investigated, the possibilities of their application have been considered, and a software product model has been formed, leading to the creation of a full-fledged web application.

Based on theoretical studies, it was concluded that an effective intelligent system applicable in the field of personalized medicine should have the following fundamental functionalities:

- Storing patient data in a single digital profile;
- Data collection for digital profile formation using both manual and automatic methods;
- Tracking the dynamics. Convenient monitoring of health indicators to assess the dynamics and deviations from the norm;
- Providing individual disease predictions;
- Providing individual recommendations to the doctor and the patient;
- Providing convenient means of communication for doctors and patients.

The software product being developed is a web application that implements these capabilities using various modern libraries and artificial intelligence technologies.

This development makes a contribution to the field of personalized medicine, offering new approaches to optimize the processes of diagnosis, treatment and decision-making by doctors. Such a platform will make it possible to create medical systems that promote more effective interaction between doctors and patients, improve the quality of medical care and treatment outcomes.

ARTIFICIAL INTELLIGENCE IN MONITORING THE CONDITION OF ANIMALS IN PASTORAL LIVESTOCK FARMING

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Monitoring agricultural animals in pastoral livestock farming remains a critically important task for regions and countries with extensive livestock farming. Traditional methods, such as GPS collars, while providing accurate tracking of animals, face challenges such as high costs, maintenance complexity, and risks of equipment damage. Therefore, artificial intelligence and computer vision technologies offer innovative solutions for counting, identifying, and analyzing the condition of animals without physical intervention.

The prospects for the development of the monitoring system are associated with the expansion of its functionality. An example is the integration of video analytics to assess the weight, height, or respiratory rate of animals, as well as early disease diagnosis through the analysis of changes in behavior or appearance. An important direction is scaling the technology for various types of livestock and climatic zones, as well as its combination with GPS tracking to build herd movement maps. Additionally, the optimization of computational algorithms allows for reduced resource requirements.

To accelerate the system's work in analyzing features, the results of detection are used, and unnecessary elements that could negatively affect the analysis are removed. The obtained images are placed in a high-precision neural network to search for features, which outputs the probability of an individual matching certain features. The specificity of the high-precision neural network allows processing only morphological features, but data on height, weight, disease presence, cleanliness, etc., can be obtained. For these tasks, a neural network with the DenseNet architecture is applicable. It allows obtaining good results due to the use of long-term memory between hidden layers (see the figure).

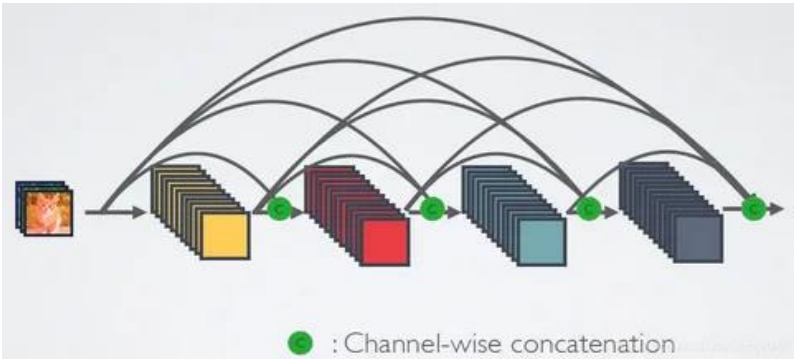

Fig. 1 Architecture of the DenseNet neural network

The representation of features is output as one or several vectors. Features in the form of numerical values are better processed using the sigmoid function, which outputs a normalized value from 0 to 1, multiplied by the vector of maximum values. Probabilities are proposed to be obtained through the softmax function, which links the classes represented in the vector. However, the main challenge is collecting data for training models, since, unlike the detection task, the analysis task requires increased diversity between individuals, as well as high-quality data labeling from animal husbandry experts.

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COMPOSITION AND META DESCRIPTIONS OF THE KNOWLEDGE WAREHOUSE COMPONENTS FOR ENERGY RESEARCH

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Working with knowledge and models of their representation is one of the main areas of research within the framework of the ecosystem of knowledge in the energy sector being developed at ISEM SB RAS [1]. Knowledge ecosystems include interconnected knowledge resources, experts, databases, knowledge bases, and knowledge repositories. Knowledge ecosystems are used as a means of interaction between participants in the process of collective knowledge exchange and for obtaining new knowledge.

Knowledge bases are an important component of the knowledge ecosystem. The knowledge base is considered as "a repository of information related to a specific subject area organized in accordance with certain principles", which "reflects the experience of specialists (experts), their understanding of the characteristics of objects and the relationships between them" [2]. In the theory of artificial intelligence, a knowledge base is a semantic model of a domain designed to accumulate new knowledge and solve applied problems. Full-fledged knowledge bases contain factual information and statements (rules of inference) that allow us to draw conclusions about existing and new facts in the subject area. Semantic processing in knowledge bases generates new knowledge. Ontological models as a variant of semantic modeling make it possible to visually display the essence of a subject area and are a means of transition from working with data to working with knowledge [3]. Creating a knowledge base involves designing its overall structure, content, tools, and interface development.

The topic of energy systems research covers a large number of terms in the subject area – concepts of ontology. The formalized description of ontologies ensures their structuring and reflection of interrelations. The developed ontological knowledge portal provides structuring and integration of ontologies of different sections of research in the subject area of energy [4]. To form a complete knowledge base, the ontology of a knowledge domain must contain information about the properties of specific objects. The main components of knowledge bases for energy research are physical energy facilities and their characteristics.

When solving different research tasks, different properties and characteristics of objects are used. For example, to describe a CHPP facility, the main characteristics are the type of installation, the type of fuel used, installed capacity, thermal capacity, efficiency, and others. The choice of these parameters is determined by an expert - specialist in a specific subject area.

There are no generally accepted methods for organizing and defining knowledge repositories. Unlike data warehouses, knowledge warehouses are more focused on high-quality data [5]. Knowledge is integrated from distributed sources and can include databases and data warehouses, news articles, online resources, as well as expert knowledge.

Meta descriptions of knowledge repository components should include such characteristics that provide search capabilities based on different criteria. Such meta descriptions, agreed upon with domain experts, can be used to create and use knowledge bases for various sections of the domain. On the other hand, they are the basis for the formation of patterns of the ontological design of the knowledge portal, when describing classes and properties in the ontological models of the portal.

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DATA MONITORING IN MODELING AGRICULTURAL PRODUCTION

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Planning of agricultural production allows for efficient use of resources in the presence of adequate data on production processes, the influence of external factors, and sales of goods. The availability of precision farming systems, satellite information, geographic information systems, unmanned aerial vehicle data, and automated agrometeorological sites allows for a more detailed process of obtaining the necessary information, reducing the uncertainty of production and economic indicators.

One of the main characteristics of the soil is its fertility, which can be determined in different ways. During field research, specialists of agrochemical service institutions obtain data on the condition and use of crop rotation fields, crops, soil fertility characteristics, and degradation data (overgrowing, waterlogging, salinization, acidity, stoniness, and other parameters).

The technology of crop yield mapping allows to determine its heterogeneity. The sequence of the yield mapping system operation is as follows: 1) receiving GPS signals from satellites in real time; 2) connecting the readings of the yield and grain moisture sensors with the electronic map; 3) obtaining a digital yield map. The map determines areas with low yield indicators due to insufficient application of fertilizers; zones with soil compaction; zones with an insufficiently developed drainage system; zones affected by weeds and parasites.

Crop mapping can be carried out using combines. At the same time, the use of unmanned aerial vehicles to identify homogeneous areas and determine their differentiation by fertility allows for the analysis of fields quickly and with less labor costs.

The digital yield map obtained in this way, together with the agrochemical survey map, can be used to create a process map for differential application of fertilizers and chemical plant protection products.

Based on the analysis of field data monitoring, new dependencies and patterns are searched for to forecast events, control and adjust technological processes. In addition, it is possible to optimize the production of crop products using mathematical programming problems taking into account the heterogeneity of agricultural lands for the correct distribution and use of resources.

Three variants of models for optimizing the production of crop products on heterogeneous lands are proposed. Using a linear deterministic model with an objective function in the form of maximum profit, it is possible to obtain optimal solutions for the distribution of areas for different crops taking into account their heterogeneity. The parametric programming model helps to determine the optimal plan due to the predictive capabilities of trends in long-term crop yield series and the determination of factors affecting bioproductivity. The third version of the problem is associated with assessing probable damage to the crop as a result of the impact of natural and anthropogenic factors and using these results to optimize production in unfavorable conditions.

The proposed models are implemented on the example of a farm specializing in the production of grain crops.

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CONTENT

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