

Applications of artificial intelligence methods in the energy sector

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Abstract. The article describes the relevance of application of artificial intelligence technologies in the energy sector. The theoretical and practical research was conducted to summarize and substantiate the classification of artificial intelligence methods used in the energy sector. It includes three groups of methods. The analysis of domestic and foreign practice of applying artificial intelligence methods in the energy sector allowed for the identification of energy tasks that can improve the efficiency of energy enterprises. The artificial intelligence technologies should be used along with energy transformation, digital transformation, and integration of energy sectors. These processes are described in the article. A deep analysis of the application of artificial intelligence methods and tasks in the energy sector was conducted and examples of applications of artificial intelligence technologies were provided.

1 Introduction

Artificial intelligence is often mentioned in the context of technological transformation. According to experts from the energy industry, the artificial intelligence methods have a significant impact on the energy industry. The analysis of the practice of using artificial intelligence in the energy sector allowed us to identify their applications: forecasting (setting tasks for predicting the volumes of energy production and consumption, optimizing equipment operation); energy efficiency improvement (monitoring of actual energy consumption); intellectualization (monitoring the state of energy facilities and processing data, results of the operation of smart houses, load management).

Note that the forecasting mechanism is quite common and applied in the energy sector. In turn, the impact of climatic conditions on renewable energy production significantly increases the need for more accurate forecasting [3].

The improvement of artificial intelligence technologies is an important task of strategic development programs both in the Russian Federation and in foreign countries. In large energy systems, it is already impossible to do without artificial intelligence, and the list of projects in the domestic and foreign energy markets is updated annually.

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2 Materials and methods

The issue of artificial intelligence is popular and artificial intelligence technologies are being actively implemented. For example, Russian nuclear power plants have implemented a project aimed to evaluate the use of personal protective equipment by employees using the machine vision system [1]. In the nuclear power industry, projects aimed to control generating equipment by monitoring the efficiency of turbine generators and identifying defects and cracks in reactors have been implemented [15].

However, there is no systematic approach to artificial intelligence in literature. The systematic approach to artificial intelligence that involves the classification of AI methods, the analysis of AI applications, and the description of industries which use them will make it possible to plan and optimize the processes of implementing artificial intelligence technologies by energy companies [4].

Based on the analysis of theoretical aspects, the authors classified artificial intelligence methods used in the energy sector (figure 1) [5].

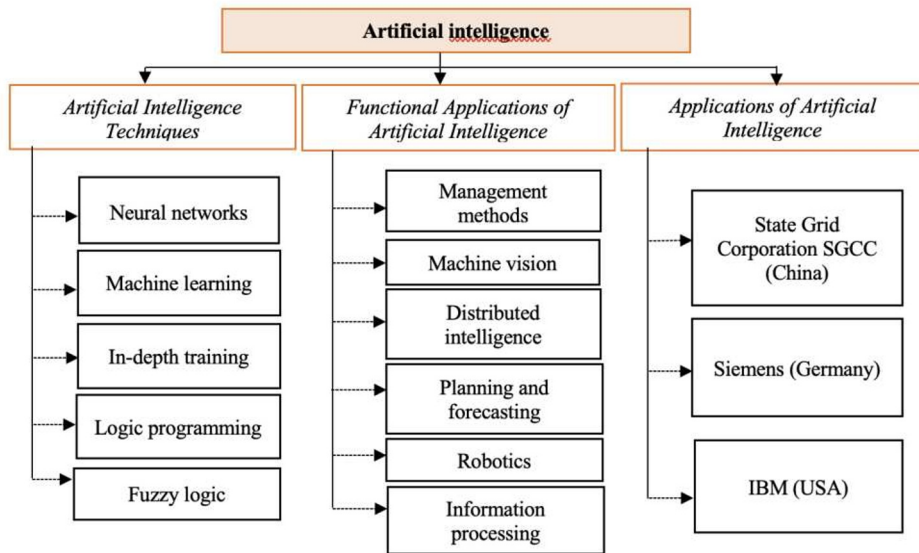


Fig. 1. Classification of artificial intelligence in the energy sector.

The classification structure involves three groups: methods of artificial intelligence, functional applications of artificial intelligence, areas of application of artificial intelligence [2;6;10].

The artificial intelligence methods were divided into five types; the method of logical programming and machine learning has a number of subgroups. It is worth focusing on the machine learning method, which has diverse types of learning technologies. This method is being actively implemented in the energy sector [7].

The functional application of artificial intelligence was divided into six groups. The distributed intelligence group was divided into several functional applications; each of them has its own functionality [9].

As for the field of application of artificial intelligence in the energy sector, the Chinese State Grid Corporation SGCC is the most active user which leads by a wide margin [8;14]. The German company Siemens and the South Korean Company Samsung can be referred to the power engineering concerns.

3 Results

Based on the results of the analysis of applications of artificial intelligence methods in the energy sector, the authors identified promising tasks where artificial intelligence can bring an effect for the energy industry (figure 2).

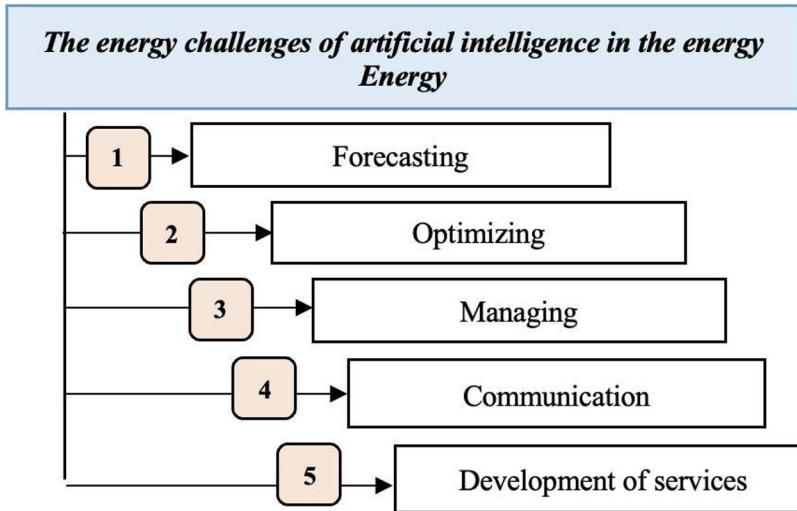


Fig. 2. Energy tasks of artificial intelligence in the energy sector

The most promising tasks of artificial intelligence in the energy sector (Figure 2) are:

- Forecasting tasks that will allow you to collect meteorological information, determine the state of power equipment, change consumption, etc [11].
- Optimization of production processes in the energy sector implies the use of modes of operation of the components of energy systems, consumption, network configuration.
- Management tasks that will allow you to manage artificial lighting, renewable energy sources and batteries, the efficiency of fixed assets [13].
- Communication tasks imply the connection of energy companies with consumers.
- Satisfaction of consumers with services provided by energy companies, participation of enterprises in the energy markets, and solution of quality assurance issues by developing services.

Note that the application of artificial intelligence in the energy sector is only possible with processes such as energy transformation, intellectualization, transmission and consumption of energy, use of Smart technologies; digital transformation driven by the growing need for monitoring and analysis of Big Data, implementation of new technologies, digital substation, use of unmanned systems to monitor facilities, integration of different sectors of the energy industry through, for example, Power-to-X technologies.

4 Discussion

Based on the results of the study of scientific and practical works, it is advisable to provide examples of applications of artificial intelligence methods in the energy sector (table 1) [2; 10-12; 14].

Table 1. Examples of Artificial Intelligence Applications in the Energy Sector.

Example and effectiveness	The method	Task in progress
XCEL, an energy provider, is using artificial intelligence models to process information. The U.S. state of Colorado is an area of application. Through the use of such models, the company is able to generate reports and optimize the operation of wind farms	Neural networks	Weather forecasting; power quality assessment; optimization of operation modes of batteries backing up renewable energy sources.
The British company DeepMind Technologies Ltd. has reduced energy consumption by forty percent by using deep learning technologies to support trading and decision-making. The parameters of the processing center, which is equipped with many sensors, have also been optimized by a trained neural network.	In-depth training	Ability to forecast electric district heating network load, losses, energy consumption and optimization, as well as to optimize the operation of hydraulic systems
German companies Evonik Steag GmbH and RWE Power AG upgraded electrostatic filters thanks to a coal-fired power plant, resulting in lower energy consumption. In turn, due to lower energy consumption, the companies have lowered their operating costs, increased the efficiency of the entire system, and reduced their environmental impact. These companies, in their activities, apply software with fuzzy logic Winpic.	Fuzzy logic	Optimization of electric filter operation at a thermal power plant; fuzzy logic relays for power transformer protection; optimization of electrical network configuration selection; artificial daytime lighting control; power plant fault diagnosis.
Schleswig-Holstein Netz AG, uses a self-learning network to detect suspected faults in the operation of electrical networks. This company uses information about the age of network components and repairs performed. The company also has information on climatic conditions and loads as basic data. All this allows the company to monitor and recognize the state of the energy sector and provides an opportunity to forecast generation. The U.S. company IBM and the U.S. Department of Energy are implementing self-learning software as a reliable predictor of renewable energy generation.	Machine learning	Renewable energy forecasting; energy optimisation; identification of grid faults; indoor comfort improvement with energy optimisation; energy statistics and monitoring; energy trading; communication with consumers.

5 Conclusion

It is already difficult to do without artificial intelligence in energy systems. The energy systems continue to develop and modern technologies will process an increasing amount of information, on the basis of which optimal operating modes of the energy systems will be created. The use of artificial intelligence methods and technologies make energy tasks presented in the current study more relevant. Therefore, there is no doubt that the role of the energy industry as one of the most interesting areas of application of AI methods will be strengthened.

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