RESEARCH AND DEVELOPMENT ACTIVITIES

The Company's R&D management activities are regulated by relevant internal documents that establish uniform requirements for the organization, planning, accounting, control of execution and acceptance of R&D commissioned by KEGOC JSC. R&D is considered as a process that covers the entire life cycle from defining tasks to evaluating and taking into account the actual effect of using the development results in the Company's practical activities.

Conducting R&D in the Company is aimed at achieving the Company's strategic goals in accordance with the KEGOC JSC Development Plan and KEGOC JSC Innovation and Technology Policy.

The main goals of organizing R&D in a Company are:

- creation, systematization and development of R&D planning and execution processes, taking into account their priority and relevance for the innovative and technological development of the Company;
- ensuring effective interaction of processes related to the development and use of scientific and technical products;
- implementation of R&D results to improve the efficiency and quality of production and business processes;
- monitoring the achievement of targets.

The main directions of technological development of KEGOC JSC are:

- innovations;
- R&D;
- innovation and inventive activities.

KEGOC JSC technological development indicators over the past 5 years

	2020	2021	2022	2023	2024
Total costs, million tenge, including for:	**1,887.43**	**236.97**	**3.72**	**15.09**	**56.75**
Innovations	1,834.97	215.50	-	-	-
R&D	45.14	19.80	-	-	43.55
Innovation activities	7.32	1.67	3.72	15.09	13.20
Number of employees engaged in research activities, people	26	26	26	26	26

Implemented projects of technical and economic research (IRE), scientific research (R&D) and development work (R&D)

№	Project name	Implementation year
1	R&D on reducing power losses in 500 kV PTL with OPGW	2017–2020
2	R&D "Study of the effectiveness of AVR settings of system power plants to ensure static and dynamic stability of 500-220 kV NPG of the Republic of Kazakhstan"	2018–2022
3	Feasibility study on the development of algorithms and creation of WACS automation based on WAMS synchrophasor measurements	2019–2020
4	R&D on identifying factors and sources of insulation contamination of electrical equipment "Western MES"	2021
5	Feasibility study on the possibility of using energy storage for UPS of the Republic of Kazakhstan	2021
6	Feasibility study on digital substation technologies	2021
7	Feasibility study on the selection of FACTS devices for reactive power compensation in UPS of the Republic of Kazakhstan	2021–2022
8	Feasibility study on the necessity of grounding shielding sheaths of control cables at substations with microprocessor-based relay protection and automation devices	2023–2024

INNOVATION AND INVENTIVE ACTIVITIES

Innovation and inventive activity (IIA) is carried out in accordance with the "Rules of Organization of Innovation and Inventive activity in KEGOC JSC and its subsidiary organization."

The main advantage of IIA is the opportunity for each employee to participate in this process, which in turn makes it possible to minimize the time from birth to the implementation of an idea and reach the maximum number of employees of the Company.

The IIA defines ideas that can be applied in other departments of the Company and provides conditions for scaling the offer. The main objectives of the IIA organization are:

◆ activation of IIA and further development of mass technical creativity of the Company's employees and UP to;
◆ increasing the interest of the Company's employees and employees in the results of their work by providing moral and material incentives to the IIA.

In 2024, 16 applications were recognized as innovation proposals and remuneration was paid for innovation proposals in the amount of KZT 13,199 million.
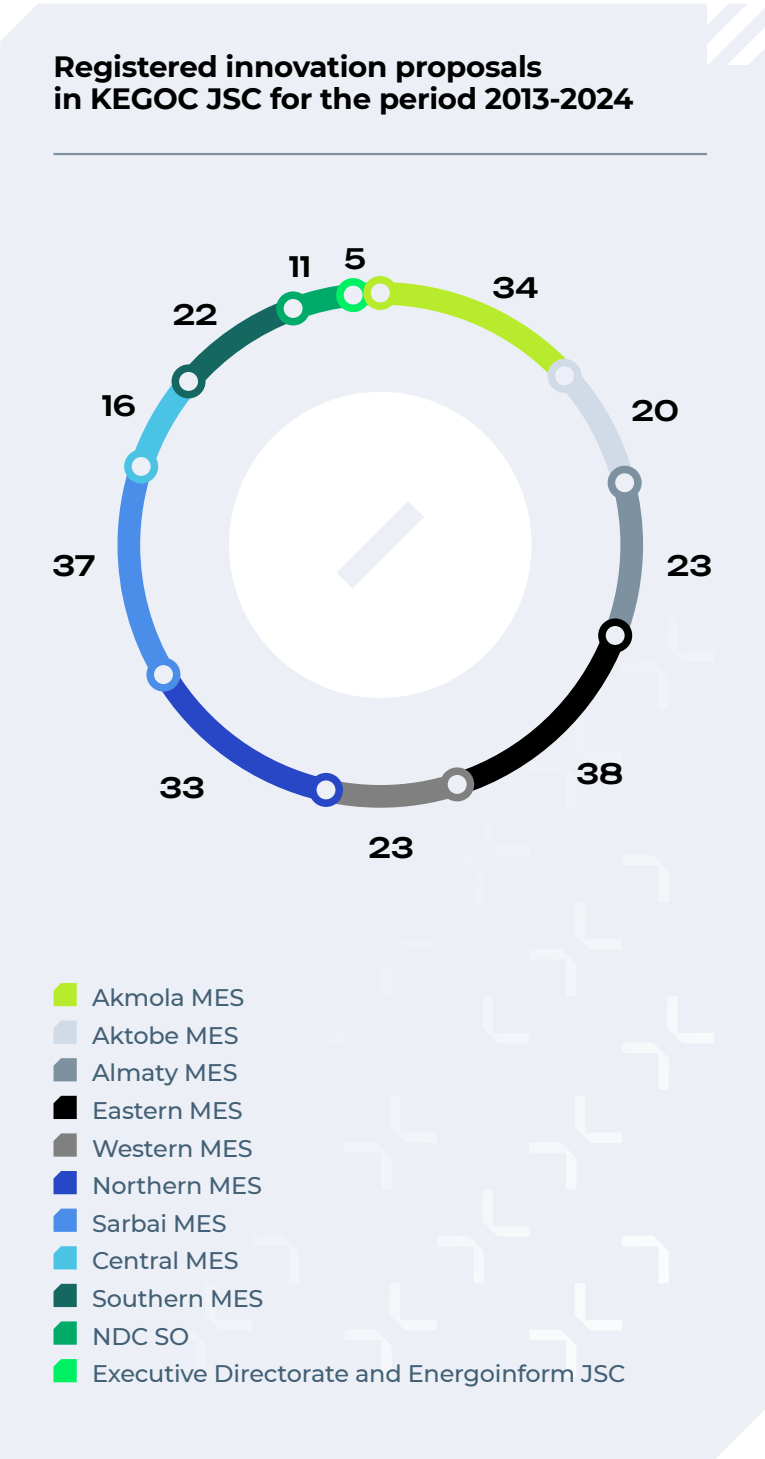
13.199
million tenge

rewards paid for innovation proposals in 2024

In total, 278 innovation proposals were registered at KEGOC JSC during the period 2013-2024.

Registered innovation proposals in KEGOC JSC for the period 2013-2024

Values around the chart: 5, 34, 11, 22, 16, 20, 37, 23, 33, 38, 23

Legend:
- Akmola MES
- Aktobe MES
- Almaty MES
- Eastern MES
- Western MES
- Northern MES
- Sarbai MES
- Central MES
- Southern MES
- NDC SO
- Executive Directorate and Energoinform JSC

INNOVATIONS

According to the global trend, KEGOC JSC continues to work in the field of modern innovative and digital technologies, based on the introduction of various elements of intelligent management of network facilities (measurement, monitoring, control and management systems), on the basis of which a new generation of electric networks, the so-called "Smart Grid", can be created.

Within the framework of these global trends, the "Concept for the development of the Electric Power industry of the Republic of Kazakhstan for 2023-2029" has established an indicator for the creation of an "Intelligent Energy System". This system will provide data collection and processing, decentralized management of energy systems, integration of distributed generation, including RES, decision-making based on synchrophasic measurements and the introduction of FACTS devices. To implement the concept, the Ministry of Energy of the Republic of Kazakhstan has developed a technology architecture for all structures of the country's fuel and energy complex (FEC).

SASB IF-EU-420A.2

The Company has implemented information systems such as SCADA, AFPC, TsSPA, WAMC, WACS, ASCAPC, SMiU, FOCL, Electricity Market Balancing System, and BIS. Among these, the 100% implementation of ASCAPC technology is particularly noteworthy.

As part of the implementation of the Smart Grid concept, KEGOC JSC has identified three main areas of digitalization of production processes that correspond to the Architecture of Digital information systems FEC (Fig. 17):
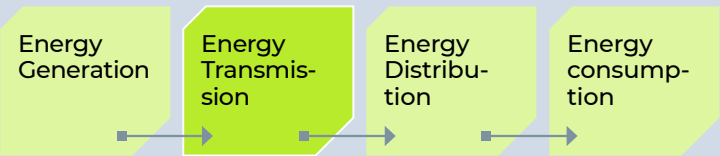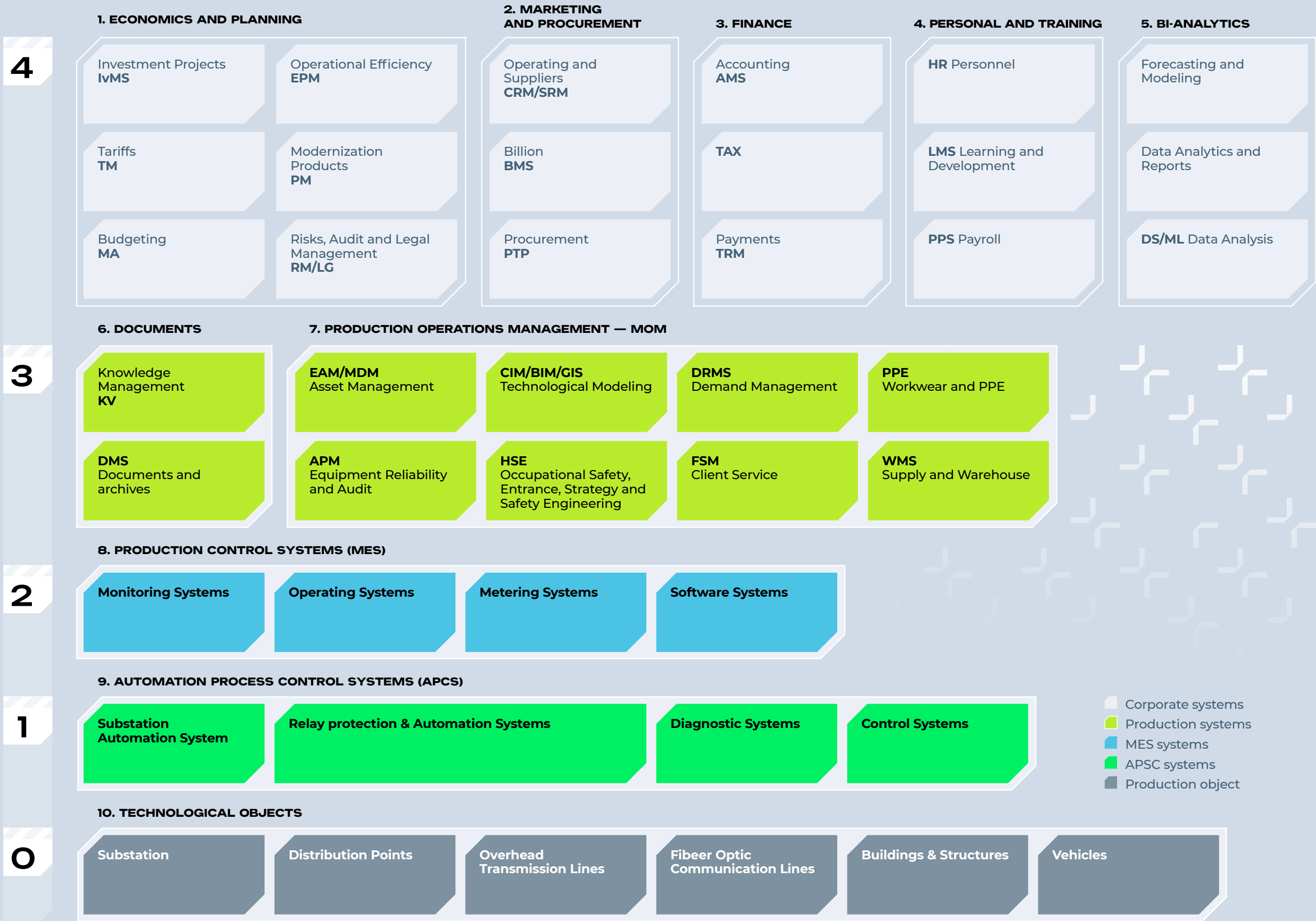
1. **Production Operations Management (MOM)** is aimed at improving the reliability and efficiency of production operations, minimizing downtime and optimizing resources.
2. **Production Management Systems (MES)** provide real-time monitoring, accounting, and management of production processes, including power system management and process monitoring.
3. **Automated control systems of technological processes (ACSTP)** automation and control of technological processes, including substation systems, relay protection, diagnostics and emergency automation.

In the three above-mentioned areas, projects are currently being implemented to modernize the SCADA/EMS system and introduce a monitoring system based on synchronized WAMS technologies (Stage 2), which will improve the efficiency of dispatch control and the observability of UPS operating modes in the Republic of Kazakhstan, as well as ensure monitoring of stability reserves and assessment of the UPS status in the Republic of Kazakhstan.

In 2024, the Pilot Project "Introduction of Electricity Storage Systems in UPS RK" (Pilot Project) continued to be implemented to study the impact of electricity storage systems on UPS regulation when integrating RES with China Power International Development Limited, China Power International Holding Limited and the Association of Renewable Energy of Kazakhstan. According to the Pilot project, it is planned to install an electricity storage system with a capacity of 3.45 MW and a capacity of 7.72 MWh.

Also in 2024, work on the project "Development of algorithms in the Centralized Automatic frequency and power control system for managing electricity storage systems" was completed. The aim of the project is to increase the reliability of Kazakhstan's NPG while integrating RES through the introduction of electricity storage systems (ESS). As part of the project, algorithms for automatic frequency and power control (AFPC) were developed to control the Electric energy storage system as a separate type of facility, taking into account their features and technical limitations.
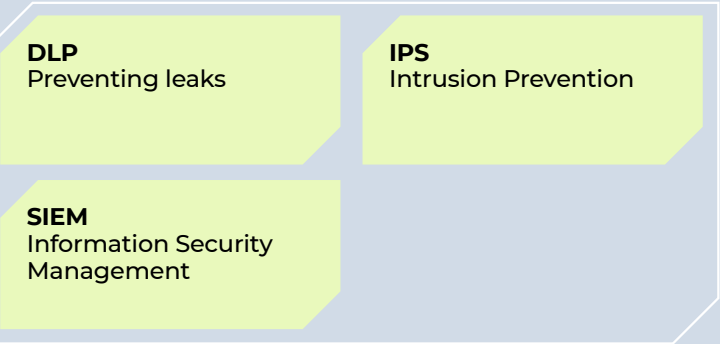
KEGOC

01

02

O3

04

05

06

07

Architecture of digital information systems FEC

1. ECONOMICS AND PLANNING

4

Investment Projects
IvMS

Operational Efficiency
EPM

Tariffs
TM

Modernization Products
PM

Budgeting
MA

Risks, Audit and Legal Management
RM/LG

2. MARKETING AND PROCUREMENT

Operating and Suppliers
CRM/SRM

Billion
BMS

Procurement
PTP

3. FINANCE

Accounting
AMS

TAX

Payments
TRM

4. PERSONAL AND TRAINING

HR Personnel

LMS Learning and Development

PPS Payroll

5. BI-ANALYTICS

Forecasting and Modeling

Data Analytics and Reports

DS/ML Data Analysis

6. DOCUMENTS

3

Knowledge Management
KV

DMS
Documents and archives

7. PRODUCTION OPERATIONS MANAGEMENT — MOM

EAM/MDM
Asset Management

CIM/BIM/GIS
Technological Modeling

DRMS
Demand Management

PPE
Workwear and PPE

APM
Equipment Reliability and Audit

HSE
Occupational Safety, Entrance, Strategy and Safety Engineering

FSM
Client Service

WMS
Supply and Warehouse

8. PRODUCTION CONTROL SYSTEMS (MES)

2

Monitoring Systems

Operating Systems

Metering Systems

Software Systems

9. AUTOMATION PROCESS CONTROL SYSTEMS (APCS)

1

Substation Automation System

Relay protection & Automation Systems

Diagnostic Systems

Control Systems

10. TECHNOLOGICAL OBJECTS

O

Substation

Distribution Points

Overhead Transmission Lines

Fibeer Optic Communication Lines

Buildings & Structures

Vehicles

KEGOC

Energy Generation

Energy Transmission

Energy Distribution

Energy consumption

11. INFORMATION TECHNOLOGY (IT)

AD/SSO
Users and initial Access

IT Assets and **HAM**

MS
Corporate Mail

ITIL Help Desk

12. INFORMATION SECURITY (ICS)

DLP
Preventing leaks

IPS
Intrusion Prevention

SIEM
Information Security Management

13. TECHNOLOGICAL PLATFORM

IT-Systems Monitoring

Kafka
Real-time Data collection

Kubernetes
Virtualization and containers

Hadoop
Data Storage and processing

CPE

Legend:
- Corporate systems
- Production systems
- MES systems
- APSC systems
- Production object
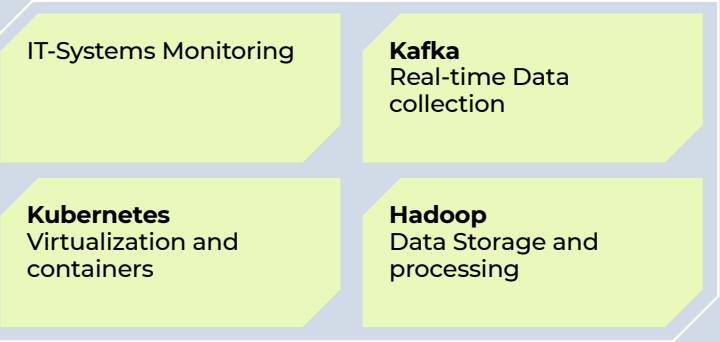
ARTIFICIAL INTELLIGENCE TECHNOLOGIES

Artificial Intelligence (AI) technologies are opening new opportunities for the energy industry, becoming a key element in the digital transformation of power systems. AI is an effective tool for solving urgent tasks such as RES integration, increasing complexity of energy system management processes and the need to improve the reliability of energy supply.

In line with global trends in the field of digitalization, the "Concept for the development of artificial Intelligence for 2024-2029" provides target indicators for increasing the number of products using AI. It provides for the implementation of AI projects, as well as support for scientific research through grant and targeted program financing.

According to the KEGOC JSC Development Plan (Strategy) for 2023-2032, the Company will continue to integrate AI technologies within the framework of building an intelligent energy system in Kazakhstan. In particular, AI will be used for the following tasks:

1. forecasting of electricity generation and consumption;
2. forecasting the technological consumption of electricity during transmission over NPG, followed by an analysis of the actual (reportable) losses of electricity by components;
3. forecasting the technical condition of production assets, detecting defects;
4. forecasting technological disruptions.

Strategic initiatives/areas of AI application

01

DEMAND FORECASTING

02

FORECASTING HOURLY LOSSES FOR THE NEXT DAY

Electricity purchases on the balancing electricity market

03

IDENTIFICATION OF HAZARD-OUS MODES OF KAZAKHSTAN'S UPS (UNIFIED POWER SYSTEM)

Monitoring and searching for "bottlenecks" in the system

04

FORECASTING HOURLY ELECTRICITY GENERATION FROM RES (RENEWABLE ENERGY SOURCES) FOR THE NEXT DAY

Increasing the accuracy of planned RES generation

05

FORECASTING TECHNOLOGICAL DISRUPTIONS RELATED TO CHANGING WEATHER CONDITIONS

Reduction of emergency outages

06

EQUIPMENT DIAGNOSTICS USING UAVS

Improving the reliability of electrical equipment operation

07

DEMAND MANAGEMENT (DEMAND RESPONSE)

Ensuring balancing reliability

08

REMOTE SUBSTATION CONTROL

Excluding unregulated switching

In 2024, in order to implement the KEGOC JSC Development Plan (Strategy), measures were launched to integrate AI technologies as part of the SCADA system modernization project. These works are aimed at:

◆ forecasting the production and consumption of electricity;
◆ forecasting of technological power consumption.

One of the key areas of 2024 was cooperation with Assystem SA on the implementation of the pilot project "Digital twin of a substation transformer". The digital transformer model will provide real-time monitoring of the condition, identify potential malfunctions and improve the accuracy of forecasts.