Furthermore, the trend toward green IoT-developing energy-efficient communication and low-power devices-will ensure environmental sustainability in digital energy transformation.

Conclusion

The implementation of IoT platforms in energy monitoring systems marks a crucial step toward the digital and sustainable evolution of the global energy industry. By linking physical infrastructure with intelligent digital platforms, IoT enables real-time control, predictive maintenance, and optimized energy management. Despite challenges related to cybersecurity, cost, and interoperability, the benefits of IoT-efficiency, reliability, and sustainability-are undeniable. As innovation accelerates, IoT will remain a key driver of smart energy systems and the foundation of the future low-carbon economy.

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ARTIFICIAL INTELLIGENCE APPLICATIONS IN ENERGY MANAGEMENT

Abstract. The rapid evolution of digital technologies has transformed the global energy sector, paving the way for intelligent, data-driven decision-making. Artificial Intelligence (AI) plays a central role in modernizing energy systems, enhancing efficiency, reliability, and sustainability across power generation, transmission, and consumption.

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ПРИМЕНЕНИЕ ИСКУССТВЕННОГО ИНТЕЛЛЕКТА В УПРАВЛЕНИИ ЭНЕРГЕТИЧЕСКИМ РЕСУРСОМ

Аннотация. *Быстрое развитие цифровых технологий преобразило мировой энергетический сектор, открыв путь к интеллектуальному принятию решений на основе данных. Искусственный интеллект (ИИ) играет центральную роль в модернизации энергетических систем, повышая эффективность, надежность и устойчивость процессов производства, передачи и потребления электроэнергии.*

In the 21st century, the energy sector is undergoing a fundamental transformation driven by digitalization, decentralization, and decarbonization. The increasing demand for electricity, combined with environmental concerns, requires new approaches to manage production, transmission, and consumption efficiently. Artificial Intelligence (AI) has emerged as a powerful tool that enables intelligent control, predictive analytics, and optimization of energy systems (IEA, 2023).

AI integrates machine learning, deep learning, and data analytics to support decision-making processes and automate complex tasks in real time. With the proliferation of sensors, smart meters, and Internet of Things (IoT) devices, vast amounts of data are generated every second. These data streams are analyzed by AI algorithms to predict consumption patterns, detect faults, and optimize energy distribution (Zhang & Wang, 2021). Thus, AI represents a cornerstone of the ongoing digital revolution in the energy industry.

Energy management refers to the systematic process of monitoring, controlling, and optimizing the generation, transmission, distribution, and consumption of energy resources. Traditionally, these processes have relied on manual supervision, historical trend analysis, and human decision-making. Such approaches, although effective in stable environments, often fail to adapt quickly to dynamic changes in energy demand, fluctuating renewable generation, and unexpected system disturbances. The growing complexity of modern energy networks — characterized by decentralized production, renewable integration, and real-time data flows — requires intelligent, automated solutions that exceed human analytical capacity (Kumar et al., 2022).

Artificial Intelligence (AI) provides the computational foundation for this transformation. Through machine learning (ML), neural networks, and advanced data analytics, AI enables the autonomous operation of energy systems, making them capable of self-optimization, prediction, and rapid response to environmental and operational variations. By continuously learning from massive data streams generated by smart meters, sensors, and

IoT devices, AI supports an adaptive energy management framework that improves both system reliability and energy efficiency (Zhang & Wang, 2021).

One of the most important contributions of AI to energy management is its ability to accurately forecast energy-related variables such as demand, generation, and market prices. Conventional forecasting models often rely on linear statistical methods that cannot handle complex, nonlinear relationships between variables. AI algorithms, especially deep learning and recurrent neural networks (RNNs), can process large-scale historical and real-time data to produce highly precise short-term and long-term forecasts.

For example, AI-based forecasting tools can predict electricity load demand by analyzing past consumption patterns, weather conditions, calendar events, and even social activities (Chen et al., 2021). Similarly, for renewable energy sources such as solar and wind power, AI models can forecast solar irradiance or wind speed with high temporal resolution, enabling operators to adjust energy storage and distribution plans efficiently. Accurate prediction reduces operational uncertainties, enhances grid stability, and minimizes energy waste.

Optimization lies at the heart of energy management. AI algorithms use optimization techniques — such as genetic algorithms, reinforcement learning, and swarm intelligence — to continuously balance the flow of electricity across the grid, minimizing losses and improving performance.

In power generation, AI optimizes unit commitment and economic dispatch problems, determining which power plants should operate and at what capacity to minimize costs while meeting demand (Gupta et al., 2022). In distribution systems, AI dynamically regulates voltage levels, reduces transmission losses, and prevents overloads by redistributing power in real time. These capabilities allow utilities to operate grids more efficiently, even under fluctuating demand or renewable generation conditions.

Moreover, AI-based control systems in smart grids are capable of real-time decision-making, enabling automated fault detection and self-healing capabilities. When a fault or power disturbance occurs, the system identifies, isolates, and restores service without human intervention. This adaptive optimization ensures both economic efficiency and operational safety.

Automation is a defining feature of AI-enabled energy management. Intelligent control systems replace traditional rule-based supervision with adaptive automation driven by machine learning algorithms. In power plants, AI-powered control rooms analyze sensor data to maintain optimal combustion conditions, turbine performance, and emission levels.

Automation also extends to microgrids and distributed generation systems, where AI coordinates distributed energy resources (DERs) — such

as rooftop solar panels, batteries, and electric vehicles — to maintain balance between local supply and demand. This decentralization enhances system resilience and reduces dependence on centralized infrastructure.

AI automation not only increases operational reliability but also significantly reduces the need for manual labor in repetitive tasks, allowing engineers to focus on strategic decision-making and innovation. As a result, operational costs decline while system performance improves.

Beyond real-time operations, AI plays an increasingly critical role in strategic decision support. Advanced data analytics platforms integrate information from production, transmission, and consumption layers to create comprehensive dashboards for decision-makers. These AI-driven decision support systems use predictive analytics, scenario simulation, and risk modeling to evaluate investment strategies, maintenance schedules, and energy policies (Wang & Lin, 2020).

For example, utilities can use AI to simulate the economic impact of adding new renewable assets, upgrading transmission lines, or implementing demand-response programs. Policy-makers, in turn, benefit from AI-based insights when designing tariffs, incentives, and national energy strategies. Thus, AI extends beyond technical optimization-it supports governance, planning, and long-term sustainability.

Collectively, these AI-driven capabilities have transformed the energy management landscape. Energy systems can now function as autonomous, intelligent ecosystems, capable of learning from historical behavior, adapting to real-time conditions, and optimizing performance without continuous human control.

The integration of AI leads to:

Higher energy efficiency, through reduced losses and optimal resource allocation;

Improved reliability and resilience, through predictive maintenance and automated fault recovery;

Lower operational costs, by reducing manual intervention and enhancing forecasting accuracy; and

Enhanced sustainability, by supporting renewable integration and emission reduction targets.

As the global energy transition accelerates, AI's role will continue to expand-serving as both a technological enabler and a strategic driver for achieving energy efficiency, sustainability, and security goals in the 21st century.

AI has become a key enabler in optimizing power generation processes. In thermal and nuclear power plants, predictive maintenance systems use machine learning to anticipate equipment failures before they

occur, minimizing downtime and operational costs (Zhou et al., 2020). In renewable energy plants, such as wind and solar farms, AI predicts weather conditions to optimize generation schedules and balance supply-demand variations.

For instance, deep learning algorithms analyze satellite and meteorological data to forecast solar irradiance and wind speed. Consequently, operators can schedule energy storage and dispatch more effectively (IEA, 2023).

AI contributes significantly to the modernization of smart grids, which integrate digital communication technologies with energy infrastructure. Smart grids enable two-way communication between consumers and utilities, improving stability and energy efficiency.

Machine learning algorithms detect faults and anomalies in transmission networks, reducing blackouts and improving reliability (Chen et al., 2021). Reinforcement learning techniques are applied to dynamically balance power flow, voltage levels, and load distribution in real time.

Furthermore, AI enables self-healing grids—systems capable of isolating faults and automatically restoring service without human intervention. These innovations are essential for managing the complexity of distributed and renewable energy sources.

Conclusion

Artificial Intelligence has become a cornerstone technology for the digital transformation of the energy sector. Its ability to analyze vast datasets, predict future trends, and automate operations leads to more efficient, reliable, and sustainable energy management systems. While challenges related to data security, cost, and regulation persist, the ongoing integration of AI promises significant improvements in both economic and environmental performance. As countries pursue energy security and climate goals, AI will remain a decisive factor shaping the future of global energy management.

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ВНЕДРЕНИЕ ЭНЕРГОСБЕРЕГАЮЩЕЙ ТЕХНОЛОГИИ ПОЛУЧЕНИЯ ПОРОШКООБРАЗНЫХ МАТЕРИАЛОВ ИЗ НЕФТЯНОГО КОКСА.

Аннотация. В данной работе рассмотрена актуальная задача разработки и внедрения энергосберегающей технологии получения порошкообразных материалов из нефтяного кокса. Исследование основано на анализе физико-механических свойств нефтяного кокса и его поведения в процессах измельчения и классификации. Предложена конструкция двухроторного конического зубчатого гравитационного классификатора, объединяющая операции дробления, разделения частиц по размеру и естественной гравитационной классификации в единую технологическую систему. Показано, что применение данной конструкции обеспечивает оптимизацию механического воздействия на частицы, снижение энергоёмкости процесса и повышение дисперсности получаемых порошков. Разработанная установка характеризуется высокой степенью эффективности (до 90–95%) и позволяет достичь непрерывного, управляемого и экологически устойчивого процесса переработки нефтяного кокса. Полученные результаты подтверждают возможность промышленного использования классификатора в технологических линиях по переработке углеродсодержащего сырья — нефтяного кокса, угля, цемента и металлургических отходов.

***Ключевые слова:** нефтяной кокс, энергосбережение, гравитационный классификатор, порошковые материалы, измельчение, фракционирование.*

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IMPLEMENTATION OF ENERGY-SAVING TECHNOLOGY FOR PRODUCING POWDERED MATERIALS FROM PETROLEUM COKE