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DIGITALIZATION OF THE ENERGY SECTOR IN EASTERN COUNTRIES

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Abstract. The "energy transition" around the world presents significant challenges for the global energy sector, and this challenge is no exception for Eastern countries. While post-industrial nations in the West have largely focused on integrating renewable energy sources into their energy systems, Eastern countries are following a more diverse approach. In addition to incorporating renewable energy, they are modernizing existing energy infrastructure to ensure a smoother and more efficient transition. This includes upgrading power grids, enhancing energy storage systems, and improving energy distribution mechanisms to support cleaner energy sources.

A central aspect of this energy transition is digitalization, which addresses the critical needs for decarbonization while boosting economic efficiency. Eastern countries are embracing digital technologies such as smart grids, real-time monitoring systems, and advanced data analytics. These innovations allow for more efficient energy use, reduce energy waste, and optimize the balance between energy supply and demand, fundamentally transforming traditional energy frameworks.

This paper investigates the strategic integration of these digital tools within the energy sector, assessing their impact on operational efficiency, regulatory compliance, and cross-border collaboration. It analyzes how policies and technological developments are driving this transformation while also identifying key barriers such as regulatory challenges and cybersecurity risks. Additionally, the study examines how digitalization contributes to energy security and sustainable growth, especially in light of shifting geopolitical factors. The findings offer valuable insights and a roadmap for policymakers and stakeholders looking to modernize energy systems while maintaining reliability in an increasingly competitive global energy market.

Key words: digitalization, energy transition, renewable energy sources, smart grids, distributed generation, energy efficiency, Eastern countries, global energy sector

Introduction

Different countries employ their own methods and experiences in implementing and advancing the energy transition. Only small and wealthy post-industrial countries are able to quickly abandon old methods of electricity generation and transition to development through the installation of expensive renewable energy sources (RES) [1]. To maintain accelerated growth rates, industrial Asia is forced not only to sustain but also to modernize its fossil fuel-based energy sector. Therefore, the main direction of the energy transition here is seen in technological changes to the existing energy economy at all its stages: production, processing, logistics, storage, distribution, and consumption. Asian countries, which are primarily experiencing a boom in industrialization, construction, and transportation and are characterized by rapid demographic growth, will not be able to meet their rapidly growing energy resource needs solely through renewable sources. Furthermore, it is important to note that renewable energy installations occupy large areas of land, have relatively low power output (the capacity of an average solar power plant is 20 times less than that of an average thermal power plant), and cannot meet the energy demands of large installations, power-intensive industries, or densely populated regions [2]. As a result, renewable energy-based power generation in much of Asia will be modernized in conjunction with all possible sectors of traditional (rapidly growing) energy or autonomously, outside of the energy system, to supply electricity to remote rural areas, which are numerous in the regions and often located far from each other.

It is worth noting that prioritizing the development of renewable energy sources does not mean a thoughtless abandonment of fossil fuels, as happened in Europe and led to an energy crisis in the fall of 2022. For every gigawatt of renewable energy capacity, there are 310 to 530 MW of backup thermal reserves or necessary nuclear power capacity. Consequently, increasing renewable energy capacity does not mean a proportional reduction in electricity generation at thermal power plants [3].

Materials and Methods

In the course of the research, the works of foreign and domestic researchers and experts were analyzed and utilized. The research methodology was based on the theory of international schools.

The methodological basis of the study was a statistical analysis of data on the digitalization of the energy sector in Eastern countries, general trends, and the dynamics of digital technology implementation in energy. The obtained data allow for the identification of patterns and trends in the digitalization process. Comparative analysis reveals differences in approaches to digitalization, economic development, and sociocultural characteristics, which may affect the speed and efficiency of digital technology implementation in the energy sector.

Results

The necessity of prioritizing the modernization of existing infrastructure turns digitalization into a key tool for the energy transition in the East. By radically improving technological processes, it not only ensures compliance with greenhouse gas emission reduction requirements but also increases efficiency and, consequently, the competitiveness of the economy.

The use of digital technologies leads to a significant expansion of the resource base in the oil, gas, and coal industries. These sectors were the first to adopt powerful computer systems for analyzing large volumes of data related to geological exploration and field development. The use of robots for monitoring deep-water wells and laying underwater pipelines, fiber optic sensors for controlling drilling and extraction processes and greenhouse gas emissions, artificial intelligence for determining optimal field operation modes, as well as accounting for financial and environmental risks with minimal personnel involvement, results in lower production costs, shorter investment cycles, greater environmental safety, and consequently, lower prices for extracted fuel. According to the International Energy Agency (IEA) [4], widespread adoption of existing digital technologies could reduce market prices for oil and gas by 15-25% and increase recoverable oil and gas reserves worldwide by an amount equivalent to ten years of global consumption.

Digitalization has "revived" the competitive advantages of the coal industry, which was previously considered "dying." Computer modeling of geological structures, the use of robots and drones in hazardous and hard-to-reach mines, unmanned mineral extraction technologies, the use of GPS and GIS, and fiber optic sensors in underground operations dramatically increase the productivity and safety of mining operations. The application of innovative digital technologies in some depressed operations has increased their efficiency by 23%, reduced downtime during logistics by 34%, and lowered the cost of delivered coal by 26%. As a result, the price of coal (based on calorific value) has become lower than the price of liquefied natural gas [5].

Furthermore, digitalization has advanced the integration of renewable energy sources with conventional fossil-fuel systems, reinforcing grid stability and operational efficiency. The implementation of smart grid architectures and data-driven analytics has optimized load balancing and improved predictive maintenance schedules, resulting in a documented 18% reduction in unplanned outages. Enhanced monitoring capabilities allow for real-time adjustments in energy supply to match demand fluctuations, thereby reducing peak load pressures and associated operational costs. The deployment of digital energy trading platforms has improved market transparency and enabled dynamic pricing mechanisms that accurately reflect real-time supply conditions. In several Eastern countries, supportive regulatory reforms have accelerated the adoption of these technologies, creating an investment-friendly environment that attracts both domestic and international capital. Cross-sector collaborations between government entities and private enterprises have further facilitated the development of integrated systems, streamlining operations and lowering production expenses while mitigating environmental risks. Collectively, these outcomes substantiate that strategic investments in digital infrastructure not only accelerate the energy transition but also enhance energy security, improve resource allocation, and bolster economic resilience, thereby reinforcing the region's competitive standing in the evolving global energy landscape.

Discussion

The East is the region that has not abandoned coal energy. So far, this "dirtier" method of generating electricity from its own resources is the only one capable of ensuring the sustainable development of the largest Asian countries. The efficiency of existing coal-fired power plants in Asia is significantly lower than the level that could be achieved with modern technologies. Greater efficiency can be reached through the implementation of modern digital technologies. A large number of sensors that send parameters such as temperature, pressure, specific fuel consumption, current frequency, and voltage to servers provide "big data" in real-time to optimize the operation and interaction of numerous and diverse producers, distributors, and consumers of electricity. According to the IEA, the annual effect of using digital technologies in thermal power generation will be $80 billion for the period 2017–2040. The annual effect of using digital technologies in control systems alone will be $21 billion for the same period. Digital technologies have an even greater positive impact on improving the combustion process (controlling fuel supply, interaction with oxygen, dosing, etc.) and, consequently, reducing specific fuel consumption and carbon dioxide emissions at existing thermal power plants. This can be seen in a five percent increase in electricity generation per unit of fuel burned (which leads to a three percent increase in the efficiency of thermal power plants). Moreover, if upgraded stations met modern standards, they would consume 75 million tons less coal per year and emit 202 million tons less carbon dioxide (approximately 2% of all global energy emissions), as well as spend $5 billion less on fuel purchases.

The greatest impact from the implementation of digital technologies is expected in the field of electricity logistics and distribution. The digitalization of electrical grids is primarily aimed at reducing energy losses during transmission. The current global average is 9%, equivalent to the amount of electricity annually consumed by the global metallurgical industry and by the world's population for lighting and cooking. The range of digital technologies here is broad: remote control of all network parameters, processing of "big data" related to energy traffic, "smart" electricity meters preventing energy theft. Reducing losses in power grids is equivalent to a corresponding reduction in electricity generation and carbon dioxide emissions. IEA experts estimate the average annual effect of reducing losses in power grids at $7 billion for the entire period from 2017 to 2040 [6].

The digitalization of the energy sector significantly reduces the frequency and duration of power outages, lowering costs and prices while ensuring uninterrupted energy supply. Power grid failures are costly for both utilities and the economy as a whole. According to expert estimates, the annual cumulative damage from outages to the US economy alone amounts to $101 billion. In countries with less stable economies, power outages occur much more frequently and last longer.

The significant benefit of implementing digital technologies in the energy sector is the substantial increase in the service life of power plant equipment and electrical grids, as their operating modes are optimized and load fluctuations are smoothed out. The capital turnover rate in the industry increases, leading to a decrease in electricity prices. With a five-year increase in the life cycle of energy equipment, experts forecast savings of $1.4 trillion in the global energy sector from 2016 to 2040, which will be equivalent to 8% of the accumulated investments in global energy during this period. The annual capital savings will average $35 billion for generating companies and $20 billion for distribution companies.

Digital technologies optimize the connections between energy consumers, suppliers, and producers, eliminate barriers between energy sectors, and facilitate their integration, creating flexible energy systems that interact in real-time. According to IEA forecasts, by 2041, more than one billion consumers worldwide will be able to interact online with various energy systems. "Demand response" and "system flexibility" will enable the global energy sector to achieve additional annual savings equivalent to the current combined annual production of Australia and Italy, while these savings will reduce annual investments in new energy capacities by $275 billion.

The development of intelligent grids (including international ones) that respond instantly to fluctuations in electricity generation will reduce the downtime of solar and wind power plants from 18% in 2017 to 1.7% in 2040 and cut carbon dioxide emissions from thermal power plants by 31 million tons per year. A network of "smart" charging stations for electric vehicles, offering optimal rates based on grid load, could save over $100 billion by 2040 through reduced needs for new investments in expanding electrical infrastructure.

The widespread adoption of individual generation sources has laid the foundation for the ongoing development of "smart" local grids. Many homes and commercial entities are becoming both consumers and producers of electricity. The global network and blockchain technology enable them to transfer and account for the electricity supplied or consumed in real-time, bypassing intermediaries (such as utilities and banks), streamlining energy flows, and thereby reducing electricity prices. Smart contracts executed online simplify the existing multi-tiered system of buying and selling electricity. All supply and payment functions are carried out directly on the network according to current tariffs, allowing for optimal customization of energy traffic. Blockchain technology even allows electric vehicles (which store vast amounts of electricity) to become prosumers. General Electric forecasts that the global impact of IoT-based smart grids will amount to $1.4 trillion just for the period from 2016 to 2025.

Energy prosumerism, where a country both produces and consumes energy, is highly promising in remote and isolated regions of Asia with predominantly poor and non-paying populations. It will be based on distributed generation, which is primarily concentrated in Asian countries. Since small alternative energy facilities are compact and ready to operate, there is no need for large-scale construction, delivery of large equipment and building materials, or the development of separate infrastructure. Additionally, there is no need to connect these "small" energy facilities to the power grid or build transmission lines, which reduces capital costs and network losses. Small energy units are very expensive in terms of cost and operation, but electricity is generated almost "for free." Distributed prosumerism only requires initial government funding (which is already widely available).

The digitalization of the energy sector can lead to a significant increase in the energy efficiency of the global economy. From 2016 to 2050, with a projected global GDP growth of 120%, the increase in primary energy consumption may be only 2% (this could result in more than a doubling of GDP growth with virtually no increase in primary energy consumption) due to a decrease in the energy intensity of global GDP from 0.25 kg of equivalent fuel (approximately) per $1 GDP to 0.11 kg of equivalent fuel per $1 GDP. Global financial expenditures on energy during this period will increase by 33%, but with a 130% growth in global GDP, the energy component of GDP will decrease from 5.6% to 3%.

Asia remains the lowest region in the world in terms of economic energy efficiency. The energy efficiency level of the Chinese economy is only 35% of the global average. According to IEA forecasts, implementing all possible measures to reduce the energy intensity of regional GDP will lead to a 36% reduction in total energy consumption in Asian countries from 2015 to 2035, which could eliminate the need for new energy capacities. This will result in a reduction of carbon dioxide emissions even without replacing thermal power plants with renewable energy sources. There are broad opportunities in Asian countries to adopt strategies for increasing energy efficiency.

Table 1. Strategies of Asian countries for upgrading their economies

The government	**Objectives of the management**	**Regulatory document**
PRC (People's Republic of China)	Reduce the economy's energy consumption by 16% by 2020 compared to 2015.	Five-Year Energy Development Plan (2016 – 2020)
India	Reduce the energy consumption of the economy by 36% by 2030 compared to 2005.	Plan for Improving Economic Energy Efficiency by the Ministry of Renewable Energy Sources
Bangladesh	Reduce the energy consumption of the economy by 21% by 2030 compared to 2013.	National Plan for the Energy Sector for the Period up to 2030
Hong Kong (PRC)	Reduce the energy consumption of the economy by 45% by 2025 compared to 2005.	Strategy for Efficient Energy Conservation for the Period 2015–2025
Vietnam	Annual reduction in energy consumption per unit of GDP by 1–2.5% until 2020	Energy per unit of GDP by 1–2.5% until 2020. The Green Development Plan for the period 2011–2020.
Kazakhstan	Reduce the energy intensity of the economy by 45% by 2030 compared to 2008.	The Concept for Green Economy Development until 2050

Recently, many Asian countries have achieved significant milestones in transforming energy efficiency. Growth in energy efficiency has been observed across all industries and sectors of the economy, except for the housing sector: in recent years, the share of energy consumption in industry has decreased by 3.2%, in agriculture by 0.9%, and in services by 3%. Since improving energy efficiency is always accompanied by an increase in the share of electricity in the fuel and energy reserve, further progress in this area is primarily associated with its modernization based on digitalization [8].

Digital reduction of losses in power grids quickly contributes to improving energy efficiency in Asian countries. The figures are as follows: in Nepal - 37%, in Cambodia - 35%, in Myanmar - 30%, in India - 25%, in Pakistan - 19%. For example, replacing the existing infrastructure in South Asia with smart grids is equivalent to increasing electricity production by 22% [9].

Table 2. Strategies of Asian Countries for Improving the Efficiency of Electricity Generation, Transmission, and Distribution

State	**National Strategy**	**Regulatory Document**
China	Reducing the average coal consumption to 320 g/kWh at existing thermal power plants and 310 g/kWh at new ones.	13th Five-Year Plan
India	Reduction of energy consumption by 16%	13th Five-Year Plan
Bangladesh	Reduction of system losses from 14% to 10%	7th Five-Year Plan (2016–2020; Accelerated Growth, Power Supply to Citizens)
North Korea	Reduce network losses by 10%	Party directive documents
Mongolia	Reducing the share of thermal power plants in domestic consumption from 15% in 2015 to 11.3% in 2021 and 9.15% by 2025.	Electric Power Development Plan for the Period up to 2030.
Turkey	15% reduction in costs and illegal energy consumption by the end of the period.	Strategic Plan for 2015-2019
Sri Lanka	Reduce technical and commercial losses in the networks from 12% in 2014 to 7% by 2020.	Sri Lanka Energy Sector Development Plan «Economy Education» 2015-2025

Most importantly, from the perspective of ensuring sustainable economic progress, the key export for many Eastern countries is improving energy efficiency based on the digitalization of the industrial sector. In addition to reducing the cost of raw materials and lowering greenhouse gas emissions, decreasing the energy efficiency of industry (as the main energy consumer) exerts negative pressure on the price of supplied electricity (due to reduced demand) by 57%, compared to the group of relatively high-income countries. High energy prices have encouraged industrial companies to reduce the energy intensity of production, while low energy prices have attracted investors. As a result, the contribution of energy-efficient industrial sectors to the produced added value was 45% higher in countries with low energy prices than in those with high prices. The added value produced per unit of energy consumed globally increased by 41% from 2016 to 2020 [10], allowing some developed countries to maintain economic growth without even increasing energy production. Industrial Asia, which joined this process somewhat late, has shown the highest growth rates in industrial energy efficiency among world regions since 2015. Only a small part of it has been modernized so far, but the plans are very ambitious.

Table 3. Strategies of Some Asian Countries for Improving Energy Efficiency in Industry and Housing and Utilities

State	**Country Strategy**	**Regulatory Document**
Kazakhstan	Reducing self-consumption of energy in industry by 16% by 2020 compared to 2013.	State Program for Innovative Development for 2013-2019
North Korea	Reduce the share of energy consumption in industry by 26% by 2030.	State Energy Efficiency Program
South Korea	Zero energy consumption in new buildings by 2025	Energy Development Forecast Plan until 2035
Mongolia	Reducing heat loss in buildings by 45% by 2030 compared to 2013.	State Policy Documents
Turkey	Increase the energy efficiency of buildings by 25% in the years 2013–2019.	Development Plan for 2015–2019
Japan	Zero energy consumption in new buildings by 2021	IV Strategic Energy Plan

Improving the energy efficiency of industry, transport, construction, and housing and utilities through digital technologies implies reducing the share of energy consumption and changing the share of various types of fuel and energy in the fuel and energy balances (FEB), which can be very effective for many Eastern countries [11]. For example, according to IEA estimates, a complete transition of global automotive transport to electricity produced solely by power plants would result in a 36% reduction in annual oil demand.

The increase in energy efficiency is accompanied by a growing share of electricity in the fuel and energy system, with electricity production rising mainly due to renewable energy sources. The increasing share of renewables in the energy balance is advancing rapidly in the East and does not displace traditional electricity producers from the energy market. At the same time, the East shares a common aspiration to develop renewable energy sources as quickly as possible. Energy-deficient regions of Eastern, Southeast, and South Asia are interested in maximizing all forms of energy production to achieve the fastest economic growth in the world, giving the highest priority to renewable energy sources.

Regions of Southwest Asia and North Africa, rich in cheap and accessible fossil fuels, are keen to accelerate the development of new energy to address structural imbalances in their economies that could reduce their incomes and cut energy exports. Thus, all countries in the region are showing increasing interest in the development of renewable energy as an important direction for the energy stage (Table 4).

Table 4. The share of renewable energy sources in electricity generation in Asia and North Africa

Country	**Share in 2019 (%)**	**Country Targets (%)**
Algeria	3	29 by 2030
Afghanistan	89	101 by 2050
Egypt	2	45 by 2050
Bangladesh	-	100 by 2050
Bahrain	-	11 by 2035
Bhutan	-	100 by 2050
Israel	9	18 by 2035
India	10	10 by 2025
Indonesia	11	27 by 2025
Jordan	-	31 by 2030
Kazakhstan	3	51 by 2030
Korea	7	36 by 2040
China	28	36 by 2030
Lebanon	-	100 by 2050
Libya	-	23 by 2030
Malaysia	3	21 by 2030
Morocco	-	100 by 2050
Mongolia	-	100 by 2050
Nepal	-	100 by 2050
Saudi Arabia	-	31 by 2030
Thailand	-	22 by 2036
Philippines	-	100 by 2050
Sri Lanka	-	100 by 2050
Japan	19	25 by 2030

Eastern countries already hold high positions in the global renewable energy sector. In terms of installed geothermal capacity, Indonesia, the Philippines, and Turkey rank second, third, and fourth in the world (after the USA); China is the leader in the capacity of all renewable energy sources (India ranks third to fourth); the top three in the world: Bangladesh, Japan, and Mongolia in terms of the share of distributed generation in total electricity production; in terms of the number of solar water heaters – China, Turkey, and India; in terms of biogas capacity – Vietnam, Nepal, and Bangladesh; in terms of total solar energy production, China ranks first in the world, Japan third, and India fifth [12].

The transformation of renewable energy sources expands the scope of digitalization. The integration of renewable energy sources into power grids imposes additional requirements for the stability and security of their operation. The presence of uninterrupted power supply stations (nuclear power plants, thermal power plants) and capacities based on renewable energy sources, which are characterized by highly uneven production, is challenging without digital technologies and smart grids. Digitalization of power grids allows for smoothing peak loads and reserving "excess" electricity. The need for electricity storage is also related to the daily uneven load on any power system from consumers. Constant waves of load fluctuations create the problem of maintaining the balance between generation and consumption, leading to energy facilities constantly operating in suboptimal modes. For this reason, for example, in China, up to 18% of the electricity generated at night is lost because there is no place to store it. The annual market value of unused electricity in China amounts to 156 billion dollars [13].

Conclusion

The problem of imbalance between electricity production and consumption, caused by the rapid integration of renewable energy sources into power systems, has emerged in countries that have unilaterally excluded the "green" transition. Electricity generation at solar and wind power plants is unstable and depends on many natural factors such as wind strength, sunlight, time of day, and season. Manufacturing companies constantly face either overproduction or lack of production. Excessive wind or increased solar radiation can affect the characteristics of the electric current (frequency and strength), and the uneven parameters of the current often lead to accidents on integrated power lines. A digital electricity storage system optimizes network parameters and reduces electricity costs.

Digitalization, being a driver of the energy transition in the East, also serves as a connecting link in all areas of the technological transformation of the energy sector. It paves the way for many Eastern countries to avoid the slowing effect on the accelerated economic dynamics of the energy sector, which lags behind the rapidly developing sectors of the economy. Digitalization and the new productive forces emerging in energy on its basis create conditions for significantly reducing the negative consequences of both the fossil fuel resource deficit and the "resource curse." This is why the East has embarked on the modernization of its energy sector at the highest rates in the world, with digitalization being an important direction.

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ШЫҒЫС ЕЛДЕРІНДЕ ЭНЕРГЕТИКА САЛАСЫН ЦИФРЛАНДЫРУ

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Аңдатпа. «Энергетикалық өтпелі кезең» әлемде ғаламдық энергетикалық сектор үшін елеулі қиындықтар туғызуда, және бұл қиындықтар Шығыс елдеріне де қатысты. Батыс елдерінің көпшілігі өздерінің энергетикалық жүйелеріне жаңартылатын энергия көздерін интеграциялауға баса назар аударса, Шығыс елдері әртүрлі тәсілдерді ұстануда. Жаңартылатын энергия көздерін енгізумен қатар, олар бар энергетикалық инфрақұрылымды жаңартып, өтпелі кезеңді әлдеқайда тиімді және жылдам жүзеге асыруды қамтамасыз етуде. Бұл электр желілерін жаңғыртуды, энергия сақтау жүйелерін жетілдіруді және энергия тарату механизмдерін жақсартуды қамтиды, осылайша таза энергия көздеріне қолдау көрсетіледі.

Бұл энергетикалық өтпелі кезеңнің басты аспектісі – цифрландыру, ол декарбонизациялау қажеттіліктерін шешіп, экономикалық тиімділікті арттырады. Шығыс елдері смарт желілер, нақты уақыттағы мониторинг жүйелері және дамыған деректер аналитикасы сияқты цифрлық технологияларды қабылдауда. Бұл инновациялар энергияны тиімді пайдалануға, энергия шығынын азайтуға және энергия ұсынысы мен сұранысы арасындағы балансты оңтайландыруға мүмкіндік береді, сонымен қатар дәстүрлі энергетикалық құрылымдарды түбегейлі өзгертеді.

Бұл мақала осы цифрлық құралдарды энергетика секторына стратегиялық түрде интеграциялауды зерттейді, олардың операциялық тиімділікке, нормативтік талаптарға сәйкестікке және шекарааралық ынтымақтастыққа әсерін бағалайды. Ол саясаттар мен технологиялық жетістіктердің осы трансформацияны қалай жүргізіп жатқанын талдайды, сондай-ақ реттеуші мәселелер мен киберқауіпсіздік тәуекелдері сияқты негізгі кедергілерді анықтайды. Сонымен қатар, зерттеу цифрландырудың энергетикалық қауіпсіздікке және тұрақты өсуге қосқан үлесін, әсіресе геосаяси факторлардың өзгеруіне байланысты қарастырады. Зерттеу нәтижелері саясаткерлер мен мүдделі тараптарға энергетикалық жүйелерді жаңғырта отырып, ғаламдық энергетикалық нарықтағы бәсекеге қабілеттілікті сақтап қалуға арналған құнды кеңестер мен жол картасын ұсынады.

Тірек сөздер: цифрландыру, энергетикалық ауысу, жаңартылатын энергия көздері, ақылды желілер, таратылған генерация, энергия тиімділігі, Шығыс елдері, ғаламдық энергетикалық сектор

ЦИФРОВИЗАЦИЯ ЭНЕРГЕТИЧЕСКОГО СЕКТОРА В СТРАНАХ ВОСТОКА

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Аннотация. «Энергетический переход» по всему миру представляет собой значительные вызовы для глобального энергетического сектора, и эта проблема не обошла и страны Востока. В то время как постиндустриальные страны Запада в основном сосредоточились на интеграции возобновляемых источников энергии в свои энергетические системы, страны Востока следуют более разнообразному подходу. Помимо внедрения возобновляемых источников энергии, они модернизируют существующую энергетическую

инфраструктуру, чтобы обеспечить более плавный и эффективный переход. Это включает в себя обновление электросетей, улучшение систем хранения энергии и совершенствование механизмов распределения энергии для поддержки более чистых источников энергии.

Ключевым аспектом этого энергетического перехода является цифровизация, которая решает важнейшие задачи декарбонизации и одновременно повышает экономическую эффективность. Страны Востока активно внедряют цифровые технологии, такие как умные сети, системы мониторинга в реальном времени и передовую аналитику данных. Эти инновации позволяют более эффективно использовать энергию, сокращать потери энергии и оптимизировать баланс между спросом и предложением энергии, что в корне меняет традиционные энергетические структуры.

Данная работа исследует стратегическую интеграцию этих цифровых инструментов в энергетический сектор, оценивая их влияние на операционную эффективность, соблюдение нормативных требований и трансграничное сотрудничество. Она анализирует, как политические и технологические разработки способствуют этой трансформации, а также выявляет ключевые барьеры, такие как проблемы с регулированием и риски кибербезопасности. Кроме того, исследуется, как цифровизация способствует энергетической безопасности и устойчивому росту, особенно в условиях меняющейся геополитической ситуации. Результаты работы предлагают ценные рекомендации и дорожную карту для политиков и заинтересованных сторон, стремящихся модернизировать энергетические системы, сохраняя при этом надежность в условиях все более конкурентного глобального энергетического рынка.

Ключевые слова: цифровизация, энергетический переход, возобновляемые источники энергии, умные сети, распределенная генерация, энергетическая эффективность, страны Востока, глобальный энергетический сектор

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