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QAZAQ GREEN

KONRAD
ADENAUER
STIFTUNG

2025

№ 12 (16) September

Qazaq Green Fest

2025

IV International Business
Festival on Renewable Energy

Energy Transformation:
From Renewables to
Alternative Energy



PROGRAMME QAZAQ GREEN FEST 2025



QAZAQ GREEN
RES ASSOCIATION

UNITED PLATFORM



for Kazakhstan and international players
in the field of renewable energy sources

AIM – SECTOR CONSOLIDATION



to bring together actors in the
field of renewable energy sources
in order to create favorable
conditions for development of the
sector

MISSION:



formation of a holistic position
of association members to
obtain attractive conditions for
investing in the projects of
renewable energy sources

Astana,
Chubary microdistrict, A. Knyaginina Str., 11

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Members and partners of the Association



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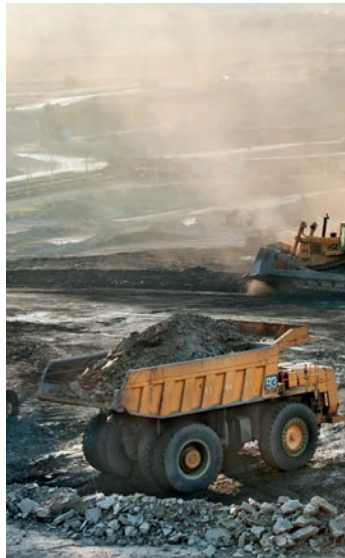


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**KONRAD
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STATEMENT BY THE PRESIDENT OF THE REPUBLIC OF KAZAKHSTAN MR. KASSYM-JOMART TOKAYEV
AT THE PLENARY SESSION OF THE ASTANA INTERNATIONAL FORUM



“

We are investing in human capital, expanding opportunities for young professionals. Our immediate task is to reduce regional disparities to strengthen our middle class.

That is why we continue to deepen our capabilities in key sectors – from digital technologies and AI to clean energy and value-added manufacturing...

But development cannot be sustainable without addressing the climate emergency. Central Asia is one of the most climate-vulnerable regions on the planet. It is experiencing warming twice as fast as the global average.

In response, we are advancing a pragmatic and regionally coordinated climate agenda. Our commitment includes membership in a number of international organizations and arrangements.

In 2026, we will host a Regional Environmental Summit in partnership with the UN – a platform to combine Central Asian strategies and global ambitions.

on May 29, 2025

Information on the production of electric energy by RES facilities for the 1st half OF 2025



INSTALLED CAPACITY

including: **3 122,12 MW**

1 570,05 MW

> Wind Farms

287,685 MW

small HPPs

Solar Power Plants



1 262,61 MW

Biogas Power Plants



1,77 MW



POWER GENERATION

including:

4 237 mln kWh



Wind Farms
2 605,9 mln kWh



Solar Power Plants
1 057,4 mln kWh



small HPP
572 mln kWh



Biogas Power Plants
1,39 mln kWh

The share of electric power generated by the RES in the total volume of electric energy production

6,81%

The increase in electric power generation by renewable energy facilities for the 1st half of 2025 compared to the 1st half of 2024 is

8,75%



DEAR READERS! DEAR FRIENDS!

Our Qazaq Green Renewable Energy Association can rightfully be called the ideological initiator, an objective witness, and an active participant in the development of the green energy sector in our country. This includes the creation of a robust legislative framework, the development of mechanisms for project implementation, and the commissioning of the first industrial-scale renewable energy facilities. These are also our first achievements – there was a time when reaching a 3% share of renewables seemed like a great success, but now, with this figure approaching 7%, it feels that we can do more, be more technologically advanced, and more competent.

In this regard, our sector, the youngest in the national economy, is constantly growing and improving. Technologies are evolving, new equipment is emerging, and the times demand new approaches. It is only natural that the legislation must also change. Therefore, this year the Ministry of Energy of the Republic of Kazakhstan has begun drafting the Law of the Republic of Kazakhstan “On the Development of Alternative Energy.” In fact, the idea of developing new legislation belongs to the President of the Republic of Kazakhstan, Kassym-Jomart Tokayev, and was announced at the fifth meeting of the National Council of Public Trust under the President of the Republic of Kazakhstan on February 25, 2021.

However, domestic experts needed time to understand and study new technologies that are not yet available in our country. These include technologies for the energy recovery of industrial and metallurgical gases, synthesis gas, the introduction of hydrogen technologies, waste heat utilization, and other technologies used for the generation of electrical and/or thermal energy. All of these technologies are reflected in the draft of the new Law. However, they must be clearly distinguished from renewable energy sources (solar, wind, and hydropower), since all of the above-mentioned technologies and energy sources are based on anthropogenic effect and are derived from industrial processes. Therefore, an important innovation is the introduction of the new concept of “non-renewable energy sources” – which, alongside renewable energy sources, will form two equally important elements of the new Law.

However, for the renewable energy sector, the draft of the new Law also offers additional opportunities for development.

THE WELCOME SPEECH OF NURLAN KAPENOV, THE CHAIRMAN OF THE BOARD OF DIRECTORS QAZAQ GREEN RENEWABLE ENERGY ASSOCIATION

First of all, thanks to the proposals of Qazaq Green Renewable Energy Association, the segment of direct contracts is to be expanded legislatively – that is, power purchase agreements concluded by a direct consumer of green energy with one or several energy-producing organizations using renewable energy sources. This is the very segment of bilateral corporate PPAs that our Association has been advocating for over the past few years – when an industrial enterprise, in order to reduce its carbon footprint, enters into a direct contract with a renewable energy generator to purchase green electricity. It is planned to enshrine in law the relationship between such projects and the Single Buyer.

According to experts, this segment has significant potential, as most companies in the real economy have adopted corporate-level strategies aimed at decarbonizing production processes. Overall, the market for direct corporate contracts could be much larger than the renewable energy auction market and could become a driver for further sector development, while not affecting tariff growth for households and businesses in the country, as the industrial consumer will be the one paying for this green energy.

Secondly, clear mechanisms for the development of energy storage systems (ESS) are emerging – including the implementation of ESS projects through the capacity market and electricity price arbitrage, as well as the introduction of the concept of “behind-the-meter” energy storage systems. These mechanisms are based on extensive international experience and fully align with the recommendations of the White Paper “Application of Battery Energy Storage Systems (BESS) in the Unified Power System of the Republic of Kazakhstan”, which

Qazaq Green Renewable Energy Association completed this year. In other words, investors will now receive clear signals on how to invest in energy storage systems as independent entities within the electricity market.

In this regard, the Qazaq Green Renewable Energy Association has initiated the IV International Business Festival on Renewable Energy Qazaq Green, which will be held on 12–13 September 2025. This year’s venue is Rixos Water World Aktau, a jewel of the Kazakh Caspian coast. The venue was chosen for a reason – it is in Mangystau Region that Kazakhstan’s first-ever bilateral corporate PPA project is taking shape: a 247 MW hybrid power plant in Zhanaozen harnessing solar, wind, and gas energy. The project is being developed by KazMunayGas NC JSC (KMG) and the Italian energy company Eni S.p.A. (Eni).

Qazaq Green Fest will bring together all key players in Kazakhstan’s renewable energy sector: representatives of government bodies, national and foreign investors, international experts and recognized global industry leaders, as well as international organizations, financial institutions, associations, and universities from Kazakhstan. Participants will have the opportunity to discuss important issues related to the development of renewable energy in Kazakhstan. All discussions will be consolidated into a Charter, that is, an Address to the Government of the Republic of Kazakhstan from the renewable energy business community on the further development of renewable energy in the country. We invite everyone interested to join our event!

The energy transformation is ongoing. Let’s take the next step together in the energy transition!

Nurlan Kapenov
Chairman of the Board of Directors
QAZAQ GREEN RES Association

Waste Management in Kazakhstan: Problems and Prospects for Technological Solutions



Yedil Zhanbyrshin,
Chairman of the Committee on Ecology and Nature Management of the Mazhilis of the Parliament of the Republic of Kazakhstan, Doctor of Technical Sciences

Global ecology and sustainable waste management have emerged as critical priorities for most nations in recent decades. Kazakhstan faces serious challenges common to many developing countries: escalating household waste volumes, inadequate technological infrastructure, deteriorating ecosystems, and the urgent need to reduce carbon emissions.

These challenges demand a comprehensive approach and innovation adoption. The key task involves overcoming existing barriers, the so-called "roadblocks", that impede the development of effective waste disposal and recycling systems. Eliminating these barriers is essential for introducing modern technologies and facilitating knowledge transfer that can fundamentally transform the current situation.

An effective waste management system, integrated into carbon neutrality strategies and based on innovative technologies with new regulatory frameworks, represents one of the primary tools for achieving climate objectives.

According to the Environmental Performance Index (EPI-2024), Kazakhstan ranks 99th out of 180 countries in waste management. Individual indicators remain concerning: 84th in waste per capita, 89th in controlled disposal, and 54th in recycling performance.

Currently, only 3.7-4% of waste undergoes recycling, while leading countries such as Germany, South Korea, and Sweden achieve recycling rates of 50-95% for municipal solid waste.

Kazakhstan stands at a crossroads: continue with the linear "collection-disposal" model or make a strategic shift toward a circular economy, where waste from one production process becomes a resource for another. The transition to such a model is ambitious yet realistic within the context of global trends and fourth industrial revolution technologies.

The key to success lies in technological transformation and implementing



advanced environmentally friendly waste management solutions. Kazakhstan must not only increase processing capacity but also develop a comprehensive, resource-oriented waste management system.

Adapting experiences from countries like China, Singapore, South Korea, Germany, Sweden, and Japan—which have successfully implemented circular economy principles using cutting-edge technologies and active legislative support—could prove instrumental in introducing advanced solutions in Kazakhstan.

THE CURRENT SITUATION IN KAZAKHSTAN

Kazakhstan generates approximately 4.5-5 million tons of solid domestic waste (SDW) annually. In 2024, over 3.8 million tons were officially collected, representing a 23.8% increase from 2022. Simultaneously,



landfill disposal levels continue rising: about 3.2 million tons were landfilled in 2024, with total landfill volumes reaching 48.3 million tons.

Since 2022, annual landfill volume increases of 10-12% significantly exceed the population growth rate of 1.3-1.4% per year.

Of the 3,016 registered landfills, only 20.7% comply with environmental standards, indicating poor oversight and inadequate infrastructure development. Regional waste sorting remains weak and inconsistent.

In 2024, 1.06 million tons of waste were sent for sorting from 19 cities. Of this amount, only 29.1% was sorted and merely 3.7% was recycled into products. Recycling capacity distribution is uneven: Astana achieves 100% utilization, Karaganda and Aktobe reach approximately 90%, Almaty attains 73%, while other regions manage 26.4-60%.

The situation proves particularly challenging in rural areas. Regions with high rural populations (Almaty, Turkestan, and Zhambyl regions) have limited or nonexistent solid waste collection and removal services. Container sites and centralized removal systems are virtually absent.

INSTITUTIONAL BARRIERS AND LEGISLATIVE FRAMEWORK

Kazakhstan's current legislative framework for waste management does not yet fully support the transition to a circular economy. The primary document, the Environmental Code of the Republic of Kazakhstan, establishes principles of "polluter pays," sustainable development, and pollution prevention. However, no specialized industry law regulates integrated waste management.

Clear regulations for separate

collection, digital accounting, and waste stream monitoring are absent, as are incentives for recycling and closed-loop systems. Coordination between the Ministry of Ecology and Natural Resources and the Ministry of Industry and Construction proves difficult, while local authorities lack funding and methodological support.

Additionally, regional waste management schemes are either nonexistent or underdeveloped, hindering the creation of unified technological chains from collection and sorting to recycling and disposal.

INTERNATIONAL EXPERIENCE AND TECHNOLOGICAL SOLUTIONS

With environmental risks escalating, increasing numbers of countries are abandoning traditional linear "production-consumption-disposal" approaches in favor of circular economy models.

Global waste management practices demonstrate several sustainable technological megatrends:

Digitalization represents the first key trend: automated accounting, real-time waste flow tracking, and sensor and analytical platform usage for managing collection, logistics, and processing.

Robotization and artificial intelligence constitute the second trend, enabling high-precision fraction sorting that significantly improves secondary resource quality and reduces contaminated raw material proportions.

Waste-to-energy (WtE) forms the third megatrend: modern waste incineration plants with multi-stage filtration and heat and electricity generation are becoming integral components of national energy systems, as demonstrated in Sweden and China.

Mobile, modular, and decentralized processing facilities

and goods, plus digital platform introduction for control and reporting.

Convergent technologies at the intersection of AI, biotechnology, nanomaterials, and sensor technology form the sixth global trend, enabling intelligent, energy-efficient, and environmentally friendly waste management solutions. Biotechnology and organic processing represent key areas for managing food and organic waste through anaerobic digestion and composting, successfully implemented in Asian countries.

It is important to note, Kazakhstan should integrate best practices from different global regions, including Europe, the United States, China, and Southeast Asian countries.

Europe: Germany, Sweden, and the Netherlands actively develop circular economies by introducing WtE plants and intelligent AI-powered robotic sorting systems. Strict environmental

by automatic filters and monitoring systems. The country imports waste from neighboring nations, viewing it as an energy resource.

Germany actively employs robotic sorting technologies with AI elements and computer vision, ensuring accurate fraction separation (paper, plastic, metal, organic matter). This increases recycling profitability and reduces contaminated recyclable materials. Germany leads in implementing the Extended Producer Responsibility (EPR) model, where companies bear packaging responsibility from production to recycling.

The Netherlands sends only 7% of waste to landfills—the remainder undergoes various recycling processes. Twenty percent of total electricity production derives from waste. Waste incineration produces steam convertible to electricity for manufacturing or home heating. Over 1 million tons of waste from major European countries including the United Kingdom, Ireland, and Italy are incinerated annually in Dutch facilities.

China generates over 230 million tons of municipal solid waste annually, making it the world's largest waste producer. Urbanization and rising prosperity have increased waste volumes, with 60-70% still landfilled. The average is 1 kg per person daily (up to 1.5-2 kg in megacities). Organic waste comprises 45-50% and plastic 15-20%.

The country actively develops waste incineration plants with multiple filtration systems, plus recycling and WtE infrastructure. The Law on Prevention and Control of Solid Waste Pollution (2016) regulates the entire waste management cycle. The national Green City program encourages waste reduction and recycling, single-use plastic restrictions exist, and Shanghai has introduced mandatory separate collection.

Key technological solutions include over 600 WtE plants, biogas plant development, chemical plastic recycling, and Extended Producer Responsibility (EPR) programs.

The Changsha experience deserves



represent the fourth trend, particularly relevant for remote and sparsely populated regions.

Extended Producer Responsibility (EPR) strengthening constitutes the fifth megatrend, requiring businesses to participate in disposing of their own products and packaging. This trend implies companies' full responsibility for collection and recycling of packaging

standards accompany green technology support measures including grants, subsidies, and regulatory sandboxes that allow real-world innovation testing with minimal administrative barriers.

Sweden has virtually eliminated landfill disposal (less than 1%). The national Waste-to-Energy system converts waste into heat and electricity, with emissions strictly controlled

special attention, where a super-eco-friendly Waste-to-Energy incineration plant has operated for several years. This WtE plant uses 9,000 tons of unsorted municipal solid waste and 1,000 tons of sludge daily as fuel to generate 200 MW of electricity.

The Pinghu Industrial Park in Zhejiang Province demonstrates a modern approach using digital platforms for real-time waste flow tracking, ensuring transparency and control at all stages. Comprehensive sludge treatment includes biochemical processing, dewatering, drying, then use in building block and cement production, plus incineration for thermal energy. Such solutions allow up to 90% sludge recycling without landfilling, significantly reducing environmental burden.

China has simplified environmentally friendly factory and waste incineration plant construction permitting, lowering barriers for foreign and private investors. The country actively develops technology incubators helping new companies adapt to local conditions and supporting innovation development.

SOUTHEAST ASIA

South Korea focuses on digital control and personal responsibility within a smart city model where household waste management uses digital platforms and IoT devices, monitoring container fill levels and optimizing collection routes. This reduces costs and improves environmental conditions.

Smart containers with RFID tags and weight sensors record disposed waste volume and type. This enables a "pay-as-you-throw" model encouraging citizens to sort and reduce waste volumes. Consequently, organic waste recycling rates exceed 95%, among the world's highest.

Singapore operates mobile waste processing units solving problems in remote and sparsely populated areas. WtE technologies are implemented through public-private partnership models (Design, Build,



Own) emphasizing innovation and efficiency. The Tuas Nexus project—integrating waste disposal and water treatment with energy autonomy and biogas technologies—exemplifies a comprehensive approach.

Singapore has implemented Extended Producer Responsibility (EPR) systems for electronic and packaging products through Producer Responsibility Schemes (PRS), including collection, recycling, reporting, and 3R (Reduce, Reuse, Recycle) program obligations.

A Regulatory Sandbox accelerates environmental innovation introduction by testing technologies with temporary regulation relaxation and risk control. WtE sector pilots include container gasifiers for bio-waste, biochar production, and reverse logistics

platforms for waste oil collection.

Singapore also employs smart containers and RFID tags for waste flow control, increasing collection and recycling efficiency.

Japan emphasizes plasma gasification, cutting-edge technology breaking down waste at temperatures above 3,000°C. This produces synthesis gas for energy generation and vitrified slag for construction. Islands are built from waste incineration slag. This virtually eliminates toxic residues and landfill needs.

Food waste produces organic fertilizers or biofuel. Recycled cooking oil converts to biofuel powering city buses and garbage trucks.

Taiwan's single landfill site could serve as a global model. According to the Taiwan Environmental Protection



Administration, 55% of all received waste is recycled. This makes the densely populated country of 23.5 million people a leader alongside Austria, Germany, and South Korea. This figure substantially exceeds the United States, where OECD data indicates approximately 35%.

Many Southeast Asian countries actively encourage foreign investors through tax breaks, grants, and subsidies for new household waste management technologies.

United States: The United States demonstrates a comprehensive approach combining legislative instruments, digital technologies, and recycling. Several states have implemented Extended Producer Responsibility (EPR) systems requiring manufacturers to assume responsibility for packaging and product lifecycle management.

IoT sensors in containers optimize collection routes, while biological

processing and composting capacities develop. Some cities implement Zero Waste initiatives aimed at reducing waste generation throughout product lifecycles.

CENTRAL ASIA

Uzbekistan leads Central Asia in WtE and waste incineration technology implementation. Several large plants built in recent years have significantly improved waste management. Modular installations in small settlements reduce infrastructure costs and increase technology accessibility.

Legislation is becoming more flexible, creating favorable investor conditions, simplifying procedures, and reducing environmental barriers. Tax incentives and subsidies support companies applying recycling innovations and environmentally friendly production for foreign technology introduction.

The Kyrgyz Republic has begun construction of three WtE plants with

the support of Chinese companies possessing state-of-the-art technologies.

Considering international experience, a strategic step toward sustainable development for Kazakhstan involves opening innovation floodgates in household waste management.

We lack civic awareness and democracy mechanisms in household waste management processes. Consistent Parliamentary and Government actions can create sustainable circular economy systems, improve citizen quality of life, and ensure long-term environmental safety.

International experience confirms that sustainable household waste management requires comprehensive approaches combining legislation, technology, and economic incentives. For Kazakhstan, the key task is removing barriers to advanced solution and technology introduction.

1. LEGISLATIVE INITIATIVES

Industry-specific law with digital accounting: Current waste regulations are scattered across the Environmental Code and subordinate legislation, lacking digital waste flow tracking systems. Expert community discussions are underway regarding new industry waste management legislation that should establish unified online platforms for waste flow accounting, monitoring, and control, becoming the regulatory foundation for sustainable waste management systems based on circular economy principles.

Current laws mention recycling and reuse but lack clear closed-cycle concepts with target indicators for reducing landfilling and increasing recycling, as in the EU.

Regional programs considering logistics: Current programs are declarative and rarely account for transport schemes and investment attractiveness. Each region needs mandatory logistics maps and economic justification.

Technological priorities: WtE is regulated by decrees (including

No. 166-p of June 13, 2025) but not legally enshrined as a priority. Robotic sorting and plasma gasification lack regulatory framework reflection, with no implementation standards or incentives.

Strengthening local authority powers and funding: Local authorities bear waste responsibility but face funding limitations. Investment attraction mechanisms and long-term recycling or WtE planning are not established.

Climate strategy integration: WtE and circular economy are tools for reducing greenhouse gas and methane emissions from landfills while increasing recycling and reuse. This will reduce carbon footprints, create jobs, and increase energy security.

2. Technological Priorities

WtE plants adapted to local conditions: Mixed waste incineration, including sludge with preliminary dewatering. Rejecting costly full sorting at initial stages, as in China.

Environmental safety: Filtration systems capturing over 98% of harmful

emissions and ash.

Pilot regions: Launching projects in capitals or large cities where waste concentration and energy networks allow WtE integration.

3. Innovation Introduction

Measures

Simplified auctions: Reducing contractor requirements while imposing high environmental requirements on supplied technologies and reducing financial guarantees.

Regulatory sandboxes: Creating technology clusters (hubs) for testing technologies with minimal administrative barriers.

EPC contracts: Comprehensive "design-procurement-construction" models for transparency and reduced lead times.

Legislative measures development: Stimulating waste management innovation.

Investment incentives: Subsidies, tax breaks, long-term contracts.

► CONCLUSION:

Solving household waste management problems requires systematic and comprehensive approaches based on modern technology combinations, effective legislation, and economic incentives.

Removing administrative and market barriers represents a key step toward building sustainable systems capable of ensuring environmental safety and economic development in Kazakhstan.

Transitioning to circular economies is impossible without innovation and creating conditions where waste becomes a resource. Success is only possible through state, business, and society partnerships supported by modern regulatory frameworks, flexible regulatory conditions, and high citizen environmental responsibility levels.



The Digital Green Bridge: From Foresight to a Global Platform for Climate Technology Transfer



The global climate agenda demands not only ambitious commitments, but also effective mechanisms to turn them into reality. Kazakhstan, which first proposed the Green Bridge Partnership Programme (GBPP) in 2010, is once again placing this initiative at the forefront of regional and international dialogue. The new phase of the GBPP involves a digital relaunch and closer integration into the UN system through ESCAP – the UN Economic and Social Commission for Asia and the Pacific.

At COP 29 in Baku, the GBPP received a new boost. The event featured the program's digital relaunch and closer integration into the UN system through ESCAP – the UN Economic and Social Commission for Asia and the Pacific.

In 2023–2024, Kazakhstan conducted the National Foresight on Green Technologies (GreenTech), which identified priority areas for sustainable development and highlighted where the country can position itself as a regional hub for climate innovation and technology transfer.

Open innovation mechanisms — including technology exchange, partnerships with international organizations, and the adaptation of global knowledge to national priorities — play a central role in the updated GBPP model. Kazakhstan is committed to engaging all elements of the innovation ecosystem: government, business, academia, and international institutions.

President Kassym-Jomart Tokayev reaffirmed this commitment at the Abu Dhabi Sustainability Week summit, where he emphasized the importance of international cooperation and outlined three guiding principles for Kazakhstan's technological agenda:

“First, ensuring that green financing becomes far more accessible. Second, expanding international cooperation in technology transfer, technical support, and scientific research. Third, fostering synergies between climate priorities, economic

development, and artificial intelligence, which by 2030 could contribute more than 16% of global GDP.”

Kazakhstan is putting these principles into practice through the GBPP, which functions as an international platform for climate technology transfer, aligning the efforts of government, science, and business.

GLOBAL CONTEXT AND CHALLENGES

The global market for green technologies is expanding at an impressive pace, with annual growth projected at 22–24% between 2025 and 2032 — far outpacing the global economy. According to Fortune Business Insights, the GreenTech market was valued at \$17.2 billion in 2023 and could reach \$105 billion by 2032.

Investment trends are equally striking: PwC reports that startups in energy technology have attracted nearly 35% of all climate-related financing. Meanwhile, developing countries will require around \$2.4 trillion annually through



By Saule Kozyke,
Deputy Chair of the Board,
International Center for Green
Technologies and Investment
Projects JSC, PhD in Economics



2030 to adapt to climate challenges.

Currently, the most advanced green technology ecosystems are concentrated in North America and Europe (44% and 40% of the world's largest innovation clusters, respectively), with hubs in Silicon Valley, Tel Aviv, Stockholm, London and Los Angeles. This underlines the need to strengthen the role of Asia-Pacific countries, including Kazakhstan in the global green technology market.

KAZAKHSTAN'S POSITION IN GLOBAL INDICES

Kazakhstan's performance in international rankings reflects both progress and persistent challenges. In 2024, the country ranked 78th out of 133 in the Global Innovation Index (GII) and 72nd out of 180 in the Environmental Performance Index (EPI), with a score of 47.8. Within the Asia-Pacific region, Kazakhstan sits in the middle tier, trailing behind innovation leaders such as Singapore, South Korea, Japan, China, India and Iran.

The GI evaluates countries across 81 indicators grouped into innovation inputs and outputs. Kazakhstan performs well in areas such as e-government, patent activity and the creative economy. However, underinvestment in the green economy, scientific research and infrastructure continues to hinder the sector's rapid development.

The EPI shows that Kazakhstan has maintained relative stability in ecosystems and biodiversity, but still struggles with air quality, waste

management and reducing greenhouse gas emissions.

According to the UN Conference on Trade and Development (UNCTAD), the countries most prepared for the green transition are the United States, Sweden, Singapore, Switzerland and the Netherlands. Kazakhstan, by comparison, ranks 68th in terms of readiness to adopt, adapt and deploy green technologies.

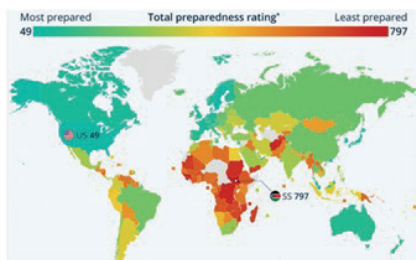
It should be noted that the current state of innovation and technological development in the industry is constrained by several factors:

- a low share of R&D expenditure on environmental protection — only 2.7% of total R&D spending;
- a marginal share of investment in the industry's fixed capital — 1.6% of total investment in the country;
- a very small proportion of environmentally friendly products in total output — just 0.2%;
- a low level of green technology adoption among major industrial polluters, with only 141 enterprises (5.5%) out of 2,554 having introduced environmentally friendly technologies;
- a limited number of green jobs — accounting for just 1.3% of total employment nationwide.

At the same time, Kazakhstan possesses significant scientific and technical potential, with 2,531 green patents and a pool of qualified specialists, yet the level of innovative activity among enterprises remains very low – around 0.3%.

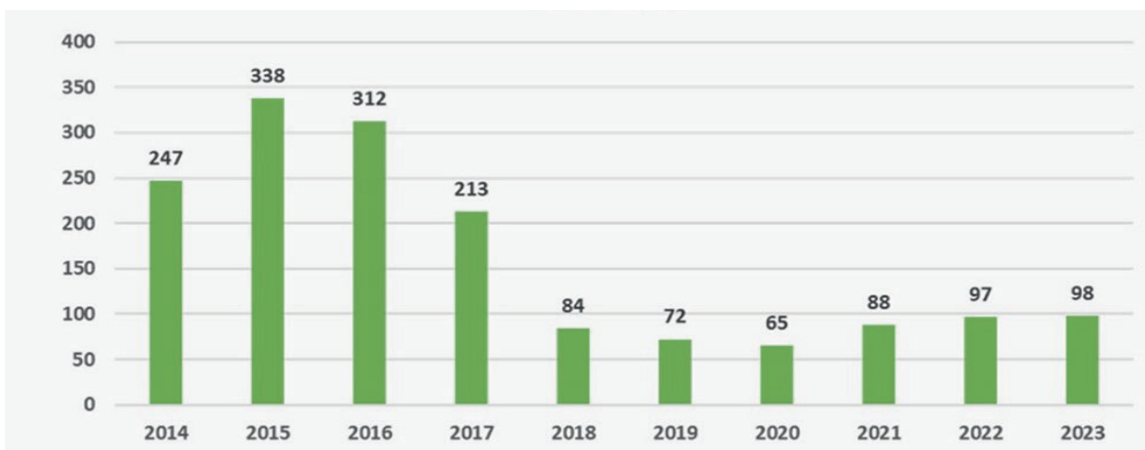
Fig.1

Overall Green Tech Preparedness Index



1 United States		6 South Korea	+1
2 Sweden	+2	7 Germany	+2
3 Singapore	+2	8 Finland	+9
4 Switzerland	-2	9 China	+6
5 Netherlands	+1	10 Belgium	+1
68 Kazakhstan	-6		

Fig. 2 Count of enterprises with environmental innovations



***Data from the Republican State Enterprise "National Institute of Intellectual Property" (QazPatent)*

Taken together, Kazakhstan's position in global rankings and these indicators suggest that, while the country possesses the necessary scientific and technical capacity and skilled human resources, it still requires systematic improvements in infrastructure, legislation, and mechanisms to support the adoption of green technologies.

SYSTEMIC CHALLENGES FOR KAZAKHSTAN IN GREEN TECHNOLOGIES

Despite progress in innovation and environmental protection, Kazakhstan continues to face systemic barriers that limit the effective transfer and deployment of green technologies:

- Technological dependence and early-stage readiness: Around 70% of technologies are imported, and many domestic projects remain at an early development stage, creating risks for localisation and commercialisation.
- Insufficient funding and incentives: R&D spending is low (2.7%), access to venture capital is limited, and there is a shortage of instruments to support innovation deployment.
- Weak science–market linkage: A large share of research remains in laboratories without reaching the market. Accelerators, technology parks and demonstration platforms are underdeveloped.
- Limited integration into global networks: Kazakhstani institutions and companies participate insufficiently in international innovation platforms,

restricting knowledge exchange and access to advanced solutions.

- Low share of green products and jobs: Environmentally friendly products make up just 0.2% of total output, and green jobs account for 1.3% of total employment. Only 5.5% of large enterprises have adopted clean technologies.

- Gaps in legislation and infrastructure: Incentives for innovation are weak, and there is a lack of demonstration centres and commercialisation support mechanisms.

GREENTECH FORESIGHT OUTCOMES

In 2023, Kazakhstan conducted its first large-scale technological foresight on green

technologies. The initiative was organised by QazInnovations JSC in cooperation with the Ministry of Ecology and Natural Resources of the Republic of Kazakhstan. The foresight identified priority areas for technological development and proposed legislative measures to stimulate innovation in the green sector.

The purpose of the GreenTech foresight is to identify priority technologies, niches, products, and services whose development will help reduce carbon emissions and support the country's sustainable development.

The analysis focused on seven priority areas: energy efficiency, renewable energy,

Fig. 3.

COVERAGE OF STRATEGIC SESSIONS





be introduced through transfer and scaling (for example, solar panels with an efficiency above 22%, wind turbines up to 5 MW, drip irrigation and precision farming systems, pyrolysis technologies).

The foresight shifted the emphasis from inventing new solutions to creating conditions for transfer and large-scale implementation, paving the way for Kazakhstan to become a regional hub for green technologies in the Asia-Pacific region.

GLOBAL GREENTECH MEGATRENDS:

- Carbon-neutral and climate technologies – advancement of CO₂ capture, utilisation, and storage (CCUS) solutions, hydrogen energy, and new types of renewable energy.
- Convergent climate technologies (NBIC) – integration of nanotechnology, biotechnology, information technology, and cognitive sciences.
- Digitalisation and smart management systems – Smart Grid, Big Data, and artificial intelligence for monitoring and optimising energy use and natural resources.
- Circular economy and waste management – transition from a linear to a circular model through recycling, reuse, and zero-waste solutions.
- Sustainable water use – technologies for purification, reuse, and reduced water consumption in production processes.

waste management, water management, green construction and utilities, clean air and green spaces and sustainable transport.

More than 670 experts from academia, business, government agencies, and international organisations took part in the study, and over 18 strategic sessions were held, making it the most comprehensive sectoral dialogue in Kazakhstan in recent years.

THE GREENTECH TECHNOLOGY FORESIGHT WAS CARRIED OUT IN FOUR STAGES:

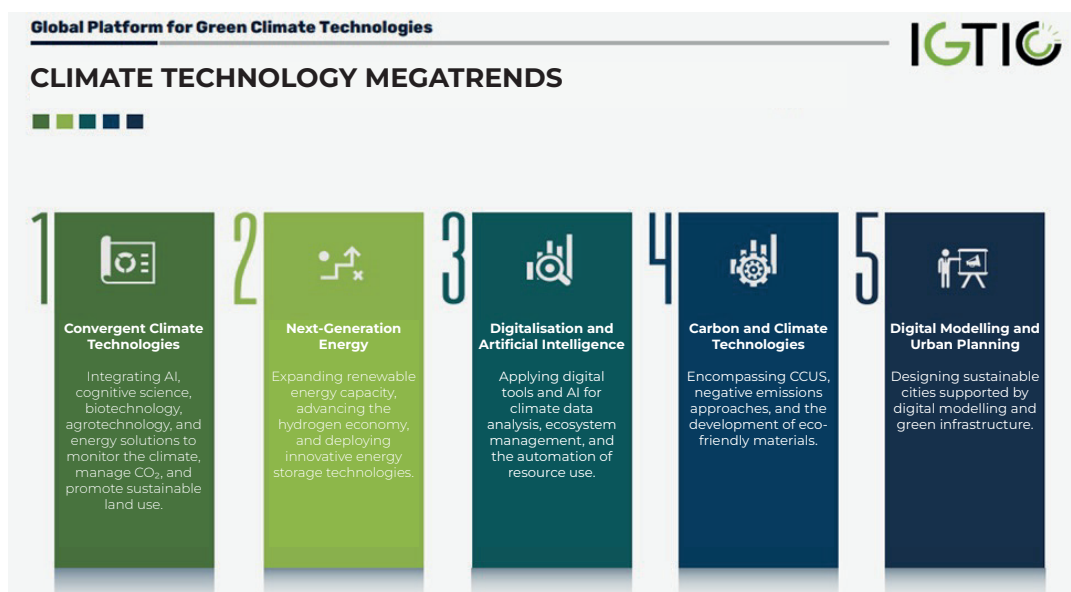
- Identification of global trends, barriers,

and key challenges in the adoption of green technologies relevant to Kazakhstan.

- Definition of technological tasks and solutions, supported by SWOT analysis and scenario planning for the development of GreenTech sectors.
- Identification of priority niches and promising products, along with an assessment of market potential for each area.
- Collection of expert recommendations and formulation of a legislative package to stimulate innovation across seven sub-sectors.

Results: More than 30% of the required technologies are already available and can

Fig. 4.



• Transport electrification and alternative fuels – mass deployment of electric vehicles, expansion of charging infrastructure, and production of biofuels and hydrogen fuels.

• Expansion of GreenTech investment and venture ecosystems – growth of the global start-up market, support for technology transfer, and climate innovation.

It is significant that experts have highlighted not only specific technologies, but also key trends shaping GreenTech: the use of digitalisation and big data for resource monitoring, rising investment in climate-focused start-ups, and the tightening of international climate commitments. Globally, the agenda is centred on reducing emissions and advancing renewable energy, while in Kazakhstan, a critical priority is adapting these technologies to the country's harsh continental climate and unique infrastructure conditions.

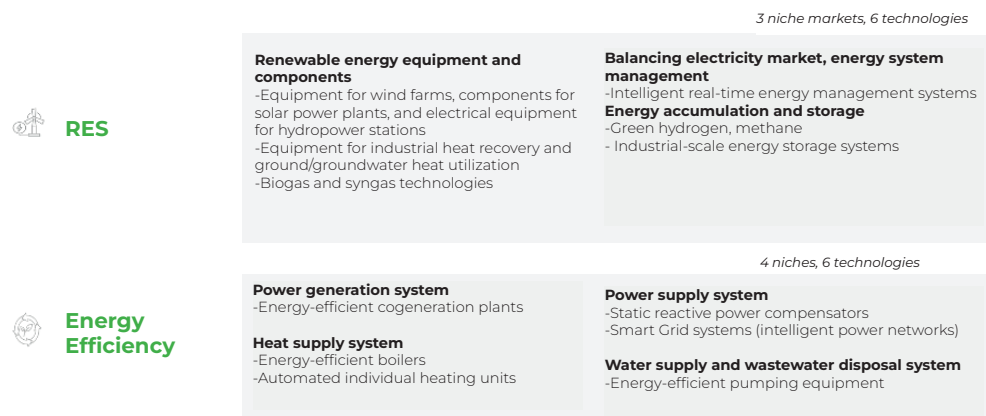
Environmental science worldwide is increasingly focused on convergent technologies (NBIC). The concept, first introduced by M. Roco and W. Bainbridge in their report *Converging Technologies for Improving Human Performance* (WTEC, 2002), emphasised that the synergy of multiple domains of knowledge generates a new technological and economic “core.”

Over the past decade, the United States has developed an innovative system of environmentally friendly technologies capable of rapidly adjusting to new technological waves. NBIC technologies are shaping the markets of the future—ranging from smart materials and personalised medicine to cognitive technologies—which, according to experts, may exert an even deeper influence on human development than nuclear technologies.

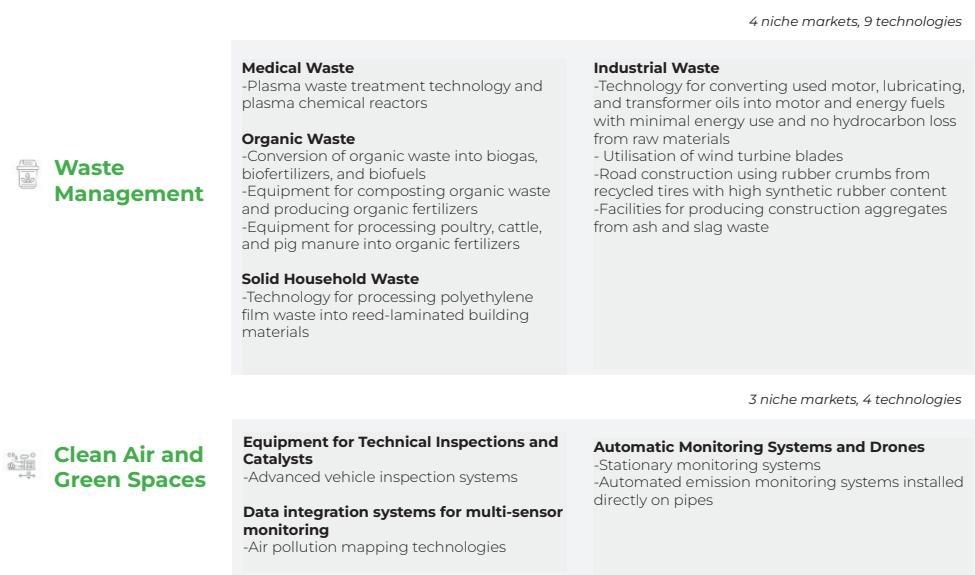
This trajectory carries particular relevance for Kazakhstan and the wider Asia-Pacific region: the transition to a green economy cannot be separated from NBIC. Developments in biofuels, hydrogen energy, clean coal technologies, and ecological big data management systems are already directly tied to NBIC-driven innovations.

Fig. 5.

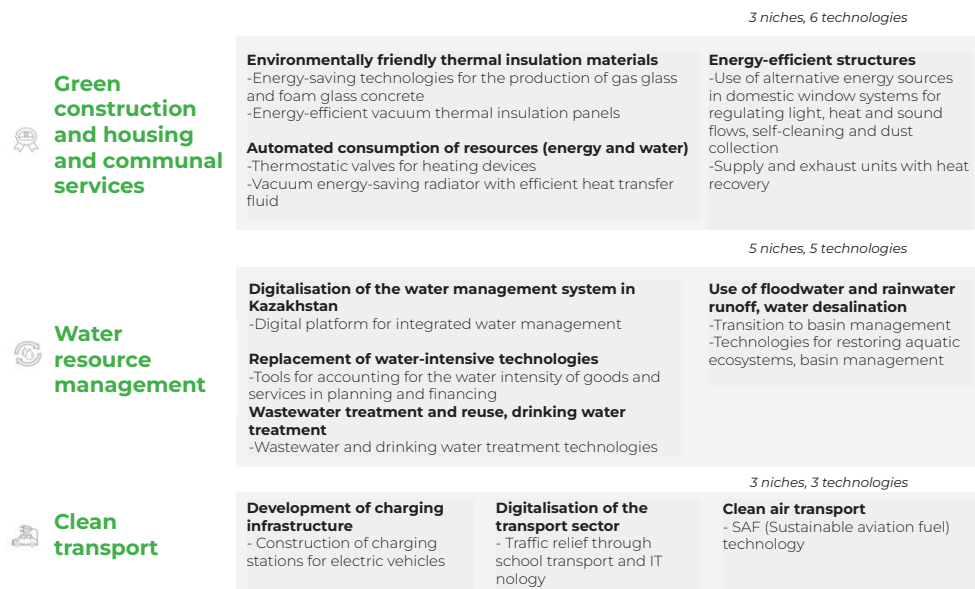
KEY SUBSECTORS, NICHE MARKETS AND GREENTECH TECHNOLOGIES



KEY SUBSECTORS, NICHE MARKETS AND GREENTECH TECHNOLOGIES



KEY SUBSECTORS, NICHE MARKETS AND GREENTECH TECHNOLOGIES



In this context, convergent technologies could provide the foundation for knowledge and technology transfer across the region, while Kazakhstan—by advancing the Green Bridge agenda—has the opportunity to act as a conduit between global scientific centres and regional priorities.

The results of the Foresight study, conducted under the auspices of QazInnovations, identified 26 priority technological niches and 39 “green” technologies for development in Kazakhstan.

In this regard, priority areas in the sphere of ecology include research on mitigating the effects of global climate change, the adoption of energy-efficient and environmentally friendly technologies, the development of alternative energy sources, hydrogen and biofuels, as well as the advancement and application of clean coal technologies.

THE GREEN BRIDGE PARTNERSHIP PROGRAMME: FROM VISION TO IMPLEMENTATION

The Green Bridge Partnership Programme (GBPP) establishes an ideological and political framework for countries transitioning toward sustainable economic models. The programme facilitates multilateral cooperation among governments, private sector entities, scientific institutions, and international organizations across Europe and the Asia-Pacific region.

The GBPP's primary objective centers on unifying efforts across diverse stakeholders—government agencies, international organizations, research institutes, and business sectors—to accelerate the adoption of advanced environmental technologies. This collaborative approach has garnered significant international recognition, including acknowledgment as the sole interregional environmental programme endorsed by the United Nations at the Rio+20 World Summit on Sustainable Development. Additionally, both ESCAP (2010) and UNECE (2011) have supported the initiative through relevant resolutions.

Currently, the GBPP encompasses 17 participating nations: Albania, Bulgaria, Germany, Spain, Poland, Serbia, Finland, the United Arab Emirates, Montenegro, Sweden, Russia, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Mongolia, and Tajikistan.

Kazakhstan has initiated a significant



renewal of the GBPP by proposing the creation of a global digital platform for green climate technologies and best available techniques.

International Promotion: The initiative has gained significant international traction through active participation at major forums: COP29, Baku, Azerbaijan (November 2024) PowerTech International Forum, Almaty (April 2025) 81st Session of ESCAP, Bangkok (April 2025) Central Asian Conference on Climate Change (CACCC) 2025, Ashgabat.

In 2024, formal communications were dispatched through the Ministry of Foreign Affairs to 17 countries that have joined the GBPP initiative.

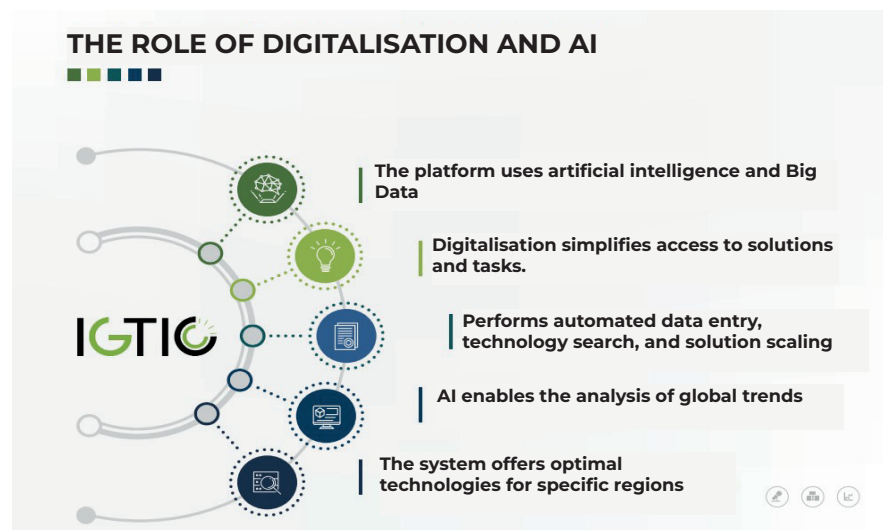
In 2025, bilateral meetings were held with key international partners, including the Embassy of the United Kingdom, the Embassy of Qatar, the EU Delegation to Kazakhstan, the Ministry of Environment of Romania, the Ministry of Ecology of Uzbekistan, the Ministry of Foreign Affairs of Turkmenistan, and the Ministry of Foreign Affairs of Azerbaijan.

DIGITAL GREEN BRIDGE PLATFORM

This proposal was formally announced at COP-29 in Baku in November 2024, marking a new chapter in international climate technology cooperation.

To advance this initiative, Kazakhstan has commenced detailed discussions with ESCAP regarding specific implementation strategies for the Green Bridge digital platform, targeting the 2025–2027 development period. The Digital Green Bridge platform represents a comprehensive ecosystem designed to integrate data, technologies, and stakeholders to accelerate global green transformation. The platform leverages artificial intelligence and big data analytics to systematize vast information flows while automating critical processes including technology identification, assessment, adaptation, and implementation.

Core platform capabilities include access to standardized methodologies and monitoring tools, Digital Measurement, Reporting, and Verification (DMRV) systems,



mechanisms for knowledge exchange and experience sharing, integration with established international platforms such as UNEP, UNIDO, IRENA, and WIPO Green, as well as the creation of a unified digital ecosystem serving scientific organizations, businesses, governments, and investors.

The Digital Green Bridge serves as the foundational infrastructure for implementing the International Technical Agreement on Climate Technology Transfer. This framework provides transparent and coordinated mechanisms for technology transfer between nations, addressing critical aspects including intellectual property protection, information technology security, and financing arrangements.

The platform establishes uniform participation conditions for all GBPP countries, accelerates the deployment of advanced environmental solutions, and reduces barriers to technology commercialization. Through predictive analytics, the system identifies promising technological solutions while strengthening Kazakhstan's position as both a regional leader and global participant in the green economy.

The proposed digital climate technology platform will enable the sharing of knowledge and experience, the adoption of best practices, and the exchange of information among GBPP countries and existing platforms, including those under

the supervision of UNECE, as well as other private and regional initiatives.

KEY FOCUS AREAS OF THE DIGITAL PLATFORM INCLUDE:

Mitigation – reducing CO₂ emissions, expanding renewable energy sources, deploying energy-efficient technologies, advancing CCUS, promoting waste recycling, and supporting the circular economy.

Adaptation – developing sustainable agriculture through drought-resistant crops and improved irrigation, enhancing water-use efficiency, building climate-resilient infrastructure, and restoring ecosystems.

The establishment of a Global Technology Transfer Platform will play a critical role in advancing international climate commitments, accelerating and strengthening the implementation of NDC, and fostering multisectoral cooperation among GBPP countries at both regional and global levels. It will also create opportunities to attract domestic and foreign investment to regions and cities, support the creation of new enterprises and green jobs, and enhance the economic and technological resilience of participating countries.

The development of a global digital platform for green climate technologies will include the following stages:

Stage 1: Technology Identification and Prioritization

The GBPP digital platform employs a

sophisticated selection methodology based on foresight analysis, industry statistics, and international benchmarking to identify technologies with significant international potential and maximum multiplier effects.

Priority consideration is given to solutions that simultaneously achieve emissions reduction, resource conservation, and productivity enhancement. Key technology categories include: solar photovoltaic systems and wind turbine technologies, energy-efficient engine systems and heat recovery solutions, advanced agricultural technologies including drip irrigation and vertical farming systems, biological pest control solutions and smart utility metering systems.

Within the GBPP digital platform, technologies with international potential and the highest multiplier effect are selected, based on foresight data, industry statistics, energy audits, and international benchmarking.

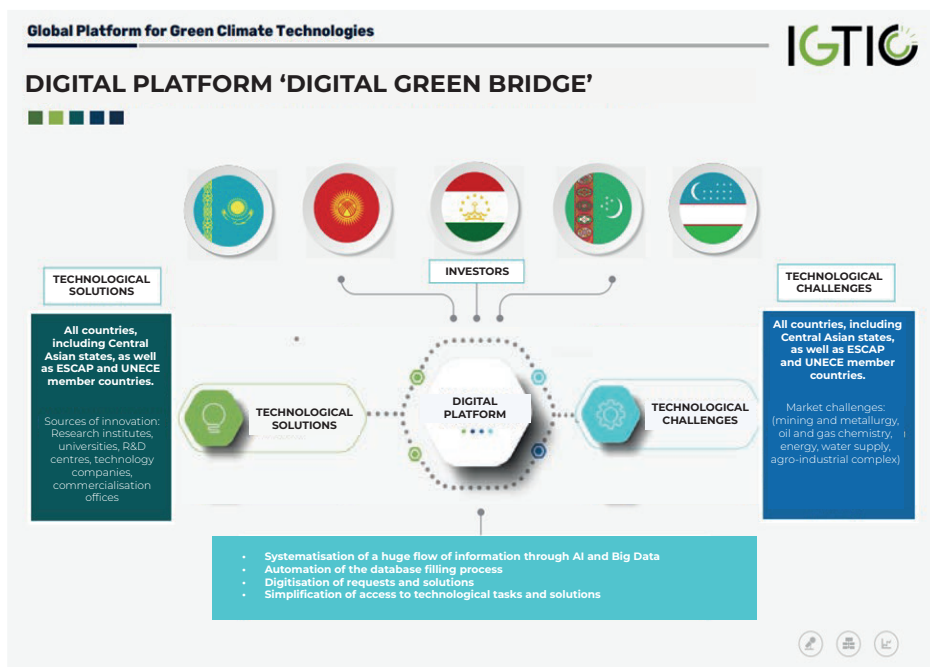
Stage 2: Technology Readiness Assessment and Local Adaptation

Each technology undergoes comprehensive analysis to determine its applicability within Kazakhstan's unique environmental conditions, including harsh continental climate, water quality variations, existing infrastructure limitations, and raw material availability.

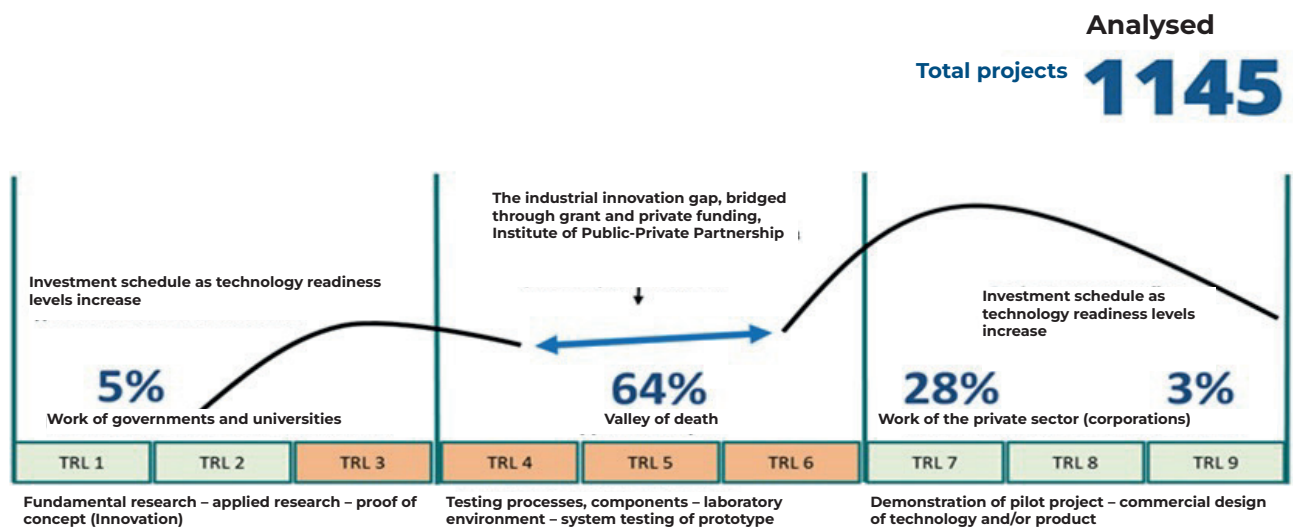
Kazakhstan's leading academic and research institutions play crucial roles in this assessment process: Nazarbayev University, Research Institute of Ecology, Al-Farabi Kazakh National University, Kazakhstan-British Technical University (KBTU), Satbayev University. These institutions contribute through regulation development, equipment adaptation, comprehensive testing, methodological guidance, personnel training, and pilot project support.

The 2023 Green Kazakhstan Foresight analysis examined 1,145 green technologies and projects, revealing that approximately 70% of initiatives are in early implementation readiness stages.

Building on this foundation, the International Centre for Green Technologies and Investment Projects conducted extensive research in 2024, collecting innovative solutions from 112 research institutes, 83 universities and 24 specialized



READINESS OF GREEN TECHNOLOGIES FOR IMPLEMENTATION



organizations. This comprehensive effort yielded 623 scientific, technical, and business projects, including 391 research initiatives and 232 business-focused projects. Significantly, over 30% of these projects have achieved commercialization readiness, including developments from the established Green Technology Register.

The December 3, 2024 agreement with The Republican State Enterprise "National Institute of Intellectual Property" and the establishment of WIPO Technology and Innovation Support Centre status provided access to international patent databases. This capability enables objective assessment of technological novelty, inventive level, and industrial applicability, confirming technology maturity and market potential.

Patent analysis has produced a preliminary catalog of 34 green technologies with demonstrated international potential. To expand research scope, the analysis incorporated international and Eurasian patent applications, creating a comprehensive foundation for the GBPP digital platform and facilitating integration with WIPO GREEN for enhanced commercialization and widespread technology implementation.

Thus, collaboration between universities, research institutes, and the

GBPP ensures a comprehensive approach to assessing technological readiness, adapting technologies, and training specialists, which accelerates deployment and enhances the effectiveness of green projects in Kazakhstan.

Stage 3: Financial Support and Implementation Incentives

To address financial barriers that often impede green technology adoption, the GBPP provides multiple funding mechanisms: grant funding for pilot project development, preferential lending arrangements, tax incentive packages, international financing through established mechanisms including the Green Climate Fund (GCF), Global Environment Facility (GEF), and Asian Development Bank (ADB). This comprehensive financial framework enables enterprises to test technologies with minimal risk while accelerating subsequent commercialization efforts.

Stage 4: Strategic Partnerships and International Collaboration

The GBPP has established collaborative relationships with leading global centers of excellence, including the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), the Climate Technology Centre and Network (CTCN), the International Renewable Energy Agency (IRENA), the United Nations Industrial Development Organization (UNIDO), the

United Nations Environment Programme (UNEP), and the World Intellectual Property Organization GREEN platform. The programme utilizes results from National Technology Assessments (TNAs) and implements various cooperation initiatives including international internships for Kazakh engineers, joint solar panel production projects with localization components, and formal agreements with South Korea on smart city development.

The strategic focus has evolved toward creating a comprehensive global digital platform for climate technologies, facilitating new country participation, information and technology exchange, partner identification, funding attraction, and project monitoring capabilities.

Based on the recommendations of the 81st ESCAP Session, the development of the GBPP focuses on creating a global digital platform for climate technologies that facilitates country accession, knowledge and technology exchange, partner identification, funding attraction, and project monitoring. The Joint Action Plan for 2025–2027, submitted to ESCAP, provides for the establishment of a digital center in Kazakhstan, transforming the country into a bridge between Europe and Asia, accelerating the exchange of green technologies in energy, transport, and agriculture, and elevating national



initiatives to the level of global climate policy. Kazakhstan is becoming a central hub for technology transfer in the region, connecting Central, East, and South Asia with the Pacific Islands.

Stage 5: Demonstration, Evaluation, and Scaling

Successful pilot projects are developed into demonstration sites across Kazakhstan. The Almaty Region showcases advanced drip irrigation systems, while the Pavlodar Region features comprehensive waste processing facilities. Astana demonstrates smart lighting infrastructure, and Shymkent implements Ydro Process wastewater treatment technology.

Economic and environmental efficiency assessments enable the creation of model solutions suitable for broader scaling. International experience from UNEP and UNIDO programmes demonstrates that this systematic approach reduces innovation implementation time by 2–3 times while decreasing piloting costs by 30–40%.

GBPP STRATEGIC SIGNIFICANCE AND FUTURE PROSPECTS

The establishment of a global GBPP platform provides a robust foundation for achieving carbon neutrality by 2060 while strengthening Kazakhstan's leadership position in the green economy. This initiative creates new opportunities for investment attraction, job creation, and technology export development.

Particular importance is placed on developing mechanisms for advanced green technology transfer and fostering active international cooperation to accelerate innovation adoption and experience sharing. Regional scaling of the GBPP by 2030 will establish a Central Asian hub for technology transfer, contributing to sustainable development across the entire region.

Long-term success requires legislative framework improvements and necessary legal amendments to ensure effective green economy functioning, reduce ecosystem burden, and enhance Kazakhstan's global competitiveness.

INCENTIVE MEASURES AND PROPOSALS FOR LEGISLATIVE AMENDMENTS IN KAZAKHSTAN

Following the GreenTech technology foresight, a package of amendments to the Environmental, Tax, and Budget Codes, the Subsoil Code, and the draft Construction Code was developed together with the expert community to drive innovation across all seven areas of green technology. These amendments were presented and discussed at a joint roundtable with the Committee on Ecology and Environmental Management of the Mazhilis of the Parliament of the Republic of Kazakhstan.

These amendments align with the green economy vision outlined in the Concept for the Transition to a Green Economy, the Strategy for Achieving Carbon Neutrality

by 2060, and related strategic documents. The initiatives focus on developing green financing mechanisms and enhancing investment attractiveness through financial institution involvement, creation of green technology infrastructure and enterprise incentive systems.

Key Legislative Priorities

- Expanding Green Financing Access involves the utilization of administrative offense fine revenues, large subsoil user participation requirements, and grant financing expansion.
- Creating a Favorable Business Environment focuses on regulatory burden reduction for green enterprises and comprehensive tax incentive packages.
- Infrastructure and Acceleration Support encompasses the establishment of the GreenTech Hub International Technology Park with tax incentives and access for foreign companies under the Astana Hub model.

This approach also requires mandatory inclusion of projects in the green technology registry to ensure consistency and transparency in support measures

GLOBAL DIGITAL PLATFORM FOR CLIMATE TECHNOLOGIES GBPP: OPPORTUNITIES, ACHIEVEMENTS, AND CHALLENGES

To date, 17 countries have already joined the GBPP, confirming the relevance of the initiative and its potential for regional and global impact.

Despite the significant potential of the Green Bridge Partnership Program—including government support, specialist expertise, and international cooperation—innovation implementation faces a number of challenges. There are difficulties with trust and coordination in the corporate sector, limited resources for project implementation, and hesitancy at the level of sectoral ministries. The lack of stimulating legislative measures further slows the process of technology transfer and implementation of innovative solutions. At the same time, new opportunities are emerging: leveraging international experience, creating high-tech jobs, and developing partnership networks between universities, business, and government. The main risk lies in the instability of the political and bureaucratic environment, as

SWOT analysis in the context of developing the Global Platform GBPP



well as insufficient long-term commitment from participants to the program's strategic objectives.

An analysis of strengths, weaknesses, opportunities and threats shows that Kazakhstan has significant potential for the development of the Green Bridge Partnership Programme (GBPP), despite the existing challenges. Strengthening the institutional base, digitizing technology transfer and actively involving international partners create the basis for overcoming the limitations identified in the SWOT analysis.

KEY STEPS FOR 2025–2027 INCLUDE INSTITUTIONAL DEVELOPMENT AND STRATEGIC PROMOTION OF THE GBPP:

- Joint Action Plan Approval:

Formalization of the roadmap between Kazakhstan's Ministry of Ecology and Natural Resources of the Republic of Kazakhstan and ESCAP, establishing long-term partnerships

- International Technical Agreement Development: Creation of comprehensive climate technology transfer framework including intellectual property, information

technology protection, and financing aspects

- Engaging new interested countries in the global GBPP platform

- Presentation of the pilot version of the global digital platform and climate technology transfer methodology at international venues, such as COP30 in Belém, Brazil, in November 2025.

- Unified Ecosystem Creation: Integration of science, business, and government stakeholders with international platforms (UNEP, UNIDO, IRENA, WIPO Green, TNA), including the participation of 17 countries to demonstrate international demand of GBPP and global expansion potential

CONCLUSION

Today, Kazakhstan has a unique opportunity to provide the world with an effective tool—the Green Bridge Partnership Programme—that will drive green technology transfer and strengthen the country's role as both a regional and global leader in sustainable development. The Green Bridge Partnership Programme represents a vital link between

global climate challenges and regional opportunities. Kazakhstan possesses the potential to become a key hub for green technology transfer in the Asia-Pacific region through strategic investment attraction, partnerships with technology leaders, and integration of national efforts into international mechanisms such as the United Nations and ESCAP frameworks.

The digital relaunch creates a unified platform for knowledge sharing, technology implementation, and climate initiative coordination.

For the successful advancement of the GBPP, it is essential to establish an open innovation ecosystem – a digital platform that brings together government, business, research centers, and international partners to accelerate the transfer of green climate technologies and enhance their accessibility.

Thus, GBPP needs to be elevated to a new stage: from a declarative initiative to a digital, technological, and institutional mechanism.

COST-OPTIMAL ENERGY SYSTEM DEVELOPMENT PATHWAYS FOR KAZAKHSTAN



Kazakhstan's energy system is facing a number of challenges, including growing demand for electricity and heat, aging infrastructure, and the need to reduce greenhouse gas emissions. Some key decisions regarding the development of the energy system have already been made, but many more are yet to come. The choices made today will determine what Kazakhstan's energy sector will look like in the coming decades: how affordable energy will be, what its environmental footprint will look like, and what kind of foundation it will provide for future economic growth.



Alexandr Gasilov,
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Eurasian Resources Group



According to the World Energy Council's energy trilemma framework, energy system planning must account for three key aspects: energy security, affordability, and environmental sustainability. The goal of this article is to identify the most balanced development scenario for Kazakhstan's energy system. The material follows a planning-based logic: how much and when new capacity should be added, which technologies are optimal, and how to handle existing power plants.

The analysis concludes that the most cost-effective and sustainable pathway for Kazakhstan is the large-scale deployment of renewables, combined with peaking gas-fired generation.

This article reflects the author's perspective on the optimal generation mix from the standpoint of minimizing energy costs. Regulatory aspects are deliberately excluded, as they require separate and more in-depth analysis.

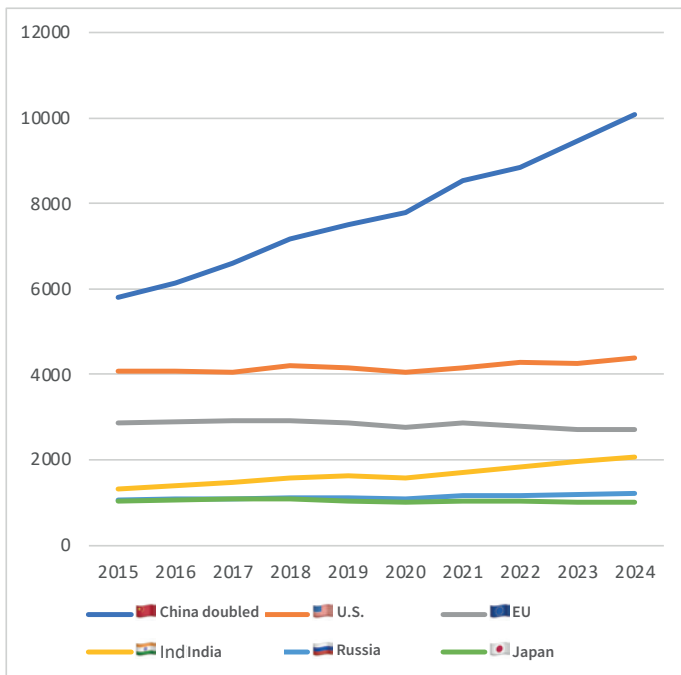
Given the discussion-oriented nature of the material, I would be glad to engage in dialogue beyond the scope of this article, answer questions, receive feedback, or share calculations if needed. You can reach me via LinkedIn: www.linkedin.com/in/alexander-gasilov.

I would like to thank my colleagues — Yevgeniy Nikitin, Nikolay Posypanko, and Timur Dyussekhanov for their valuable comments and ideas during the development of this work.

HOW MUCH OF THE NEW CAPACITY NEEDS TO BE BUILT, AND WHEN?

At the early stages of energy system planning, it is important to define the required volume of new capacity. The experience of many countries shows that

Trends in Energy Production across Selected Countries¹, billion kWh



energy demand growth rates tend to be relatively stable, as they are primarily determined by the structure of the economy and its growth pace. For example, China’s economy is highly electricity-intensive and continues to grow at a strong pace. In contrast, the share of industry in the EU is significantly lower, and GDP growth rates lag far behind those of China. Moreover, the high cost of energy resources and environmental constraints drive a strong focus on energy efficiency.

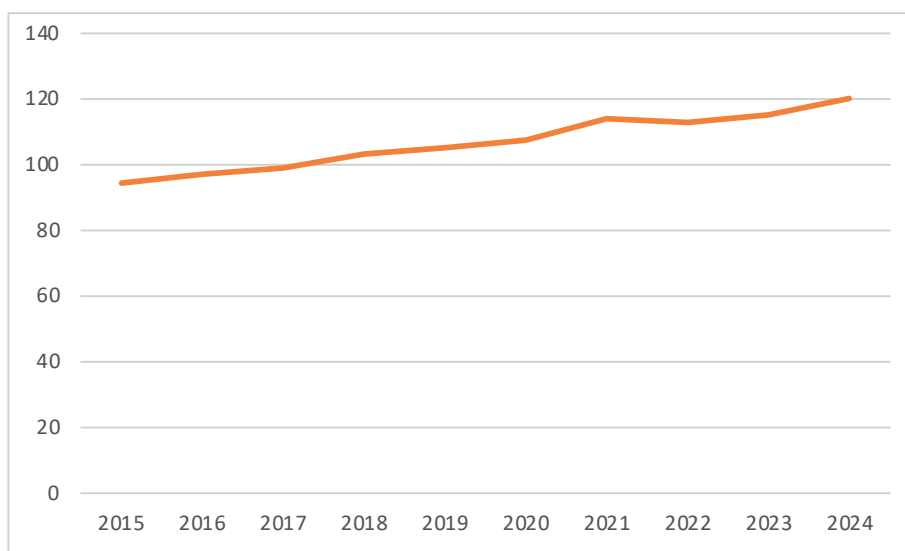
Average Annual Change in Electricity Generation Over 10 Years: China: +6.3%, USA: +0.8%, EU: -0.7%, India: +5.0%, Russia: +1.4%, Japan: -0.1%.

Compared to these countries, Kazakhstan occupies an intermediate position in terms of both the share of industry in GDP and the pace of economic growth. Over the past 10 years, electricity consumption in Kazakhstan has been growing at an average annual rate of 2.7%.



¹ <https://www.visualcapitalist.com/ranked-top-countries-by-annual-electricity-production-1985-2024/>

Electricity Consumption in Kazakhstan, billion kWh per year



Thus, to meet the growing energy needs of the economy, the required rate of generation increase should be no less than 2.7% per year. Moreover, given the recurring shortages, it should be even higher, as additional reserve capacity is needed.

There is a view that accelerated energy sector development can stimulate the emergence of energy-intensive industries. However, this requires a cautious approach. The problem is that the cost of electricity from new power plants is significantly higher than from existing ones, as, in addition to fuel and operating expenses, it is also necessary to recover the capital investment and ensure a return for investors. Today, the cost of electricity from existing thermal power plants is around 10–15 tenge per kilowatt-hour, whereas electricity from a new coal-fired plant is estimated at no less than 40 tenge (including capacity payments). Therefore, pursuing rapid energy sector expansion carries the risk of significantly increasing the cost per kilowatt-hour — both for current and future consumers. Existing consumers would end up paying for idle new capacity awaiting demand. Expensive electricity could reduce the competitiveness of energy-intensive industries and raise entry barriers for new enterprises. The key conclusion is that capacity additions must be aligned with the real needs of the economy.

An interesting example is China, which has managed to establish large-scale industrial construction of coal-fired power plants at specific capital costs below \$1,000 per kilowatt. In 2021, China announced that it would stop developing coal projects abroad and canceled more than 40 GW of coal capacity overseas. Despite this pledge, new overseas coal projects involving Chinese companies continue to surface from time to time, although their total scale is several times smaller than that of the projects that were halted¹. It is also important to note that the specific costs of Chinese contractors for international projects are significantly higher than for domestic ones.

As the economy transitions from a resource-based or industrial model to a service-based one, a decline in specific energy intensity is inevitable. Naturally, there is a possibility of the major changes driven by emerging factors such as electric vehicles, data centers, or decarbonization. However, their impact tends to unfold gradually over a period of 5 to 10 years rather than occurring within a single year.

The United States² offers a clear example of how the data center industry can affect electricity demand. Over the past five years, their share in national electricity consumption has increased from 1.9% to 4.4%. By 2028, this growth is expected to continue at least at the current pace.

Electricity Consumption by Data Centers in the U.S., billion kWh

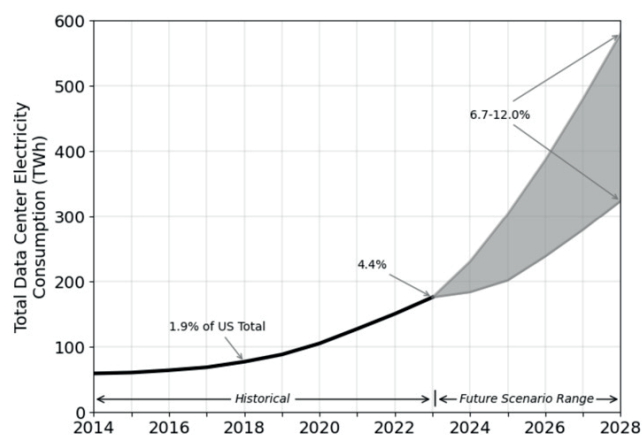


Figure ES-1. Total U.S. data center electricity use from 2014 through 2028.

¹ <https://energyandcleanair.org/publication/three-years-later-impacts-of-chinas-overseas-coal-power-ban/>

² <https://escholarship.org/uc/item/32d6m0d1>

If a similar trend were applied to Kazakhstan's power system, covering the electricity needs of data centers would require only about 100 MW of new capacity to be added each year.

The rapid surge in the digital mining industry that occurred in Kazakhstan a few years ago was largely driven by the availability of surplus capacity and the possibility of purchasing electricity directly from power plants. Under current conditions, however, this sector has sharply declined and no longer appears as attractive. Given that large-scale investment in the energy sector will inevitably drive up electricity costs, the likelihood of a similar boom occurring again in the near future appears low.

Another illustrative example is the potential electricity demand from Kazakhstan's vehicle fleet if it were fully electrified.

$$\begin{aligned} & \mathbf{5.7 \text{ million of Vehicle fleet} \times \text{consumption}} \\ & \mathbf{\text{of } 0.25 \text{ kWh/km} \times \text{average mileage of } 15,000 \text{ km/year}} \\ & \mathbf{= 21.4 \text{ billion kWh}} \end{aligned}$$

This figure is equivalent to 18% of the country's current electricity consumption. If the entire existing vehicle fleet is replaced with electric vehicles over a 20-year period, the average contribution of electrification would be less than 1% per year. Moreover, with the introduction of time-of-use electricity pricing, electric vehicles could help smooth the load curve, meaning the actual increase in required capacity would be significantly lower than 18%. In addition, each electric vehicle, effectively functioning as a mobile energy storage unit, could, with the appropriate regulatory framework in place, provide services to the grid by consuming electricity during surplus periods and supplying it back during peak demand periods.

Thus, even major factors such as data centers or transport electrification are not unexpected in energy system planning. With a certain reserve of generating capacity, such developments are unlikely to be constrained by system limitations.

Even large additional factors or individual projects do not necessarily add on top of existing growth rates and push energy consumption beyond the long-term trend. Certain sectors of the economy may stagnate or contract due to reduced output, improved energy efficiency, or other reasons.

WHAT TYPE OF NEW CAPACITY IS THE MOST ECONOMICALLY VIABLE?

To compare the cost of electricity from different types of generation, the commonly used metric is LCOE (Levelized Cost of Electricity). In this article, a simplified single-rate energy price is used for clarity. It is conceptually similar to LCOE but does not apply discounting to future generation volumes and costs. This approach allows for a straightforward comparison of new generation costs with current renewable energy auction prices and the costs of existing power plants.

$$\mathbf{\text{Price} = \text{OPEX} + \text{Fuel} + \text{PMT} (10\%; 15; \text{-CAPEX}) / \text{Sales}}$$

- OPEX – operational expenses per kWh, including staffing, maintenance, and other plant operating costs
- Fuel – fuel cost component per kWh
- PMT – an Excel function that calculates the annuity (uniform)

loan payment based on the specified loan amount, return rate, and repayment period. This component ensures both loan repayment to the bank and return on investment. Parameters used:

- 10% – project return rate
- 15 years – investment payback period
- CAPEX – capital expenditures for building the capacity
- Sales – total electricity sales in kWh
- The exchange rate used is KZT 500 per USD 1.



Assumptions and Price Calculation for Different Types of Power Plants

Indicator	Unit	Combined Cycle Gas Turbine (CCGT)	Gas Engine (GE)	Coal-Fired	Wind	Solar
OPEX	tenge/kWh	3.0	4.0	6.0	2.0	2.5
Fuel	-	gas	gas	coal	-	-
Fuel price	USD	250 per 1000 m3	250 per 1000 m3	15 per ton	-	-
Electrical Efficiency (%)	%	55%	45%	38%	-	-
Standard Fuel Consumption	g ce/kWh	224	274	324	-	-
Fuel	KZT /kWh	24.5	29.9	2.8	-	-
Specific CAPEX	USD/kW	1,200	800	2,500	700	500
Capacity Factor	%	70%	70%	70%	37%	20%
CAPEX	KZT /kWh	11.8	8.6	26.8	12.7	18.8
Price	KZT/kWh	39.3	42.5	35.6	14.7	21.3
Including CO ₂ at 50 USD/t						
CO ₂ e emissions	kg/MW	360	440	950	-	-
CO ₂	tenge/kWh	9.0	11.0	23.8	-	-
Price with CO ₂	tenge/kWh	48.3	53.5	59.4	14.7	21.3
Hot start		30-40 minutes	Less than 1 minute	Approx. 2 hours		
Ramp rate		5-10% per minute	100% per minute	1.5-3% per minute		

Notes. The gas price is based on export parity. Since the volume of gas available on the market is limited, domestic consumption reduces export potential and the opportunity to earn revenue at a rate of USD 250 per 1,000 cubic meters¹. Hydropower plants are not included due to limited capacity potential and relatively high costs combined with stability risks. The CO₂ price is assumed at an indicative level of USD 50 per tonne. Given Kazakhstan's commitment to reducing greenhouse gas emissions, such a price level can be expected over the next 10 years across the full volume of emissions (without free allowances). It is worth noting that this value is significantly lower than the expected cost of carbon capture and storage. The unit capital cost for coal-fired power plants is based on the most recent projects implemented by China abroad.²

As shown in the table above, gas and coal-fired power plants have the highest electricity cost, making them the most expensive options for consumers. For gas, this is due to the high cost of fuel; for coal — due to the high capital expenditures. If CO₂ costs are included in the calculation, coal-fired plants become the most expensive option because of their high emissions per kilowatt-hour.

The lowest electricity cost is observed for wind power, which is lower than even the fuel cost alone of the most efficient combined-cycle gas turbines (CCGTs). However, the challenge with wind power lies in its intermittency, which prevents it from being used as a standalone solution. Successful integration of wind power into the grid requires the presence of dispatchable generation that can be

activated on demand.

Given the above, the most optimal solution appears to be a hybrid system, where the bulk of electricity is provided by low-cost renewables, while reliability and periodic shortfalls are covered by generation with low capital costs, namely gas-fired power. In such a system, expenditures on expensive gas are minimal, as is the overall cost of electricity. Moreover, this system would result in minimal greenhouse gas emissions, as gas plants would operate with a low capacity factor.

The graph below shows the cost of electricity from conventional power plants depending on their capacity factor (CF).

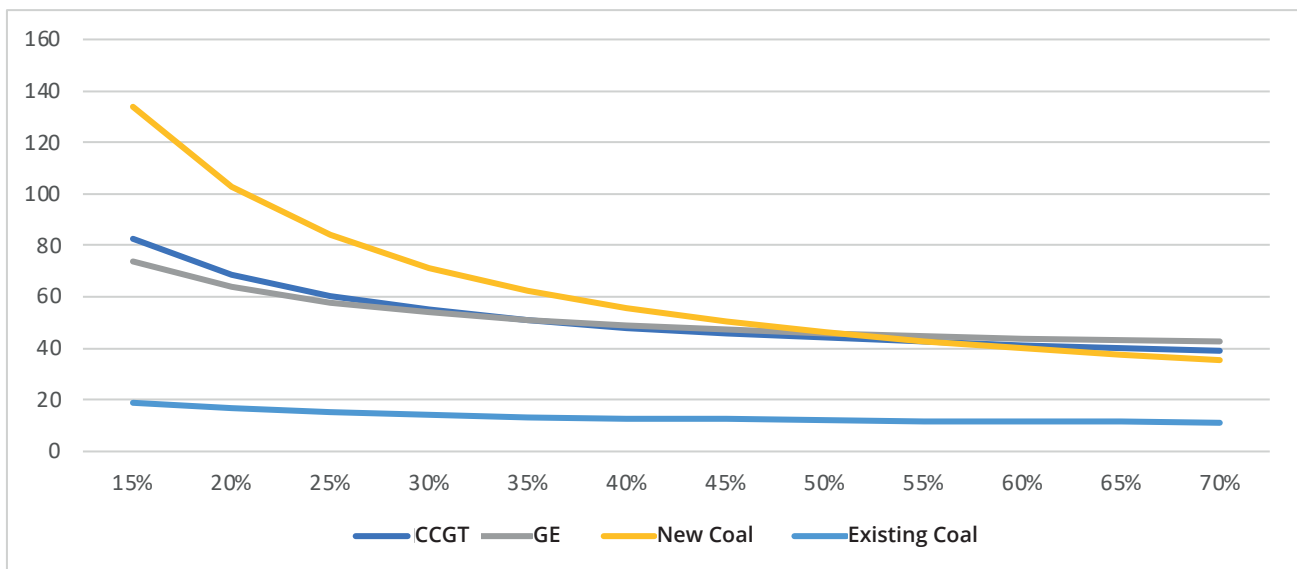
¹Export Price to the PRC in 2023

²The estimate is based on the expansion project of the Hwange coal-fired power plant in Zimbabwe, where two 300 MW units were commissioned in 2023 and 2024. The total budget amounted to approximately USD 1.4 billion, or about USD 2.5 million per MW in 2025 price terms.



The graph below shows the cost of electricity from conventional power plants depending on their capacity factor (CF).

Cost of Electricity from Different Sources at Varying Capacity Factors, KZT/kWh



Existing power plants provide the lowest electricity cost. At low capacity factors, new gas-fired plants are cheaper than new coal-fired ones. However, when operating at a capacity factor above 50%, coal plants may offer lower costs due to cheaper fuel. The most competitive tariff from new plants can be achieved with high utilization and comprises around 40 KZT per kilowatt-hour.

As noted above, the lowest cost from new generation can be achieved by leveraging the low cost of renewables. To do this, an excess amount of cheap renewable capacity must be built with the understanding that part of this energy will be curtailed when not needed. When calculating system costs, the cost of curtailed energy must also be taken into account.

The volume of curtailment has been estimated based on an hourly energy balance for the extreme case and is assumed in the article as follows:

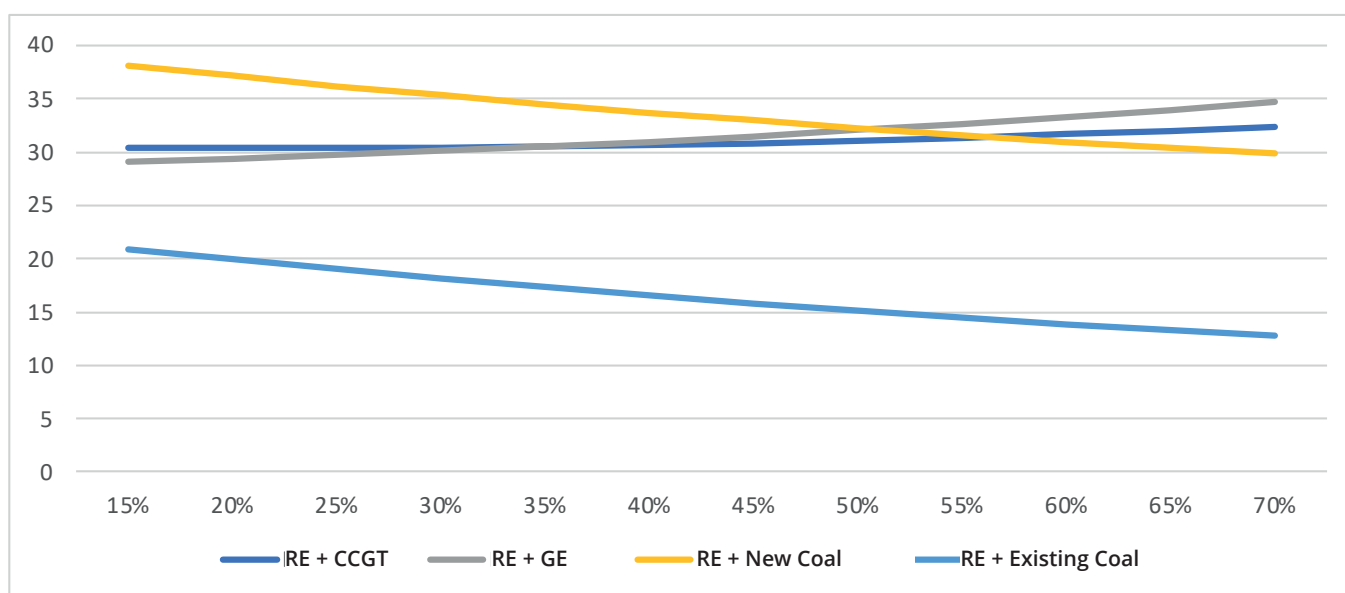
Share of Energy from Dispatchable Generation	15%	20%	25%	30%	35%	40%	45%	50%	55%	60%	65%	70%
Volume of Curtailed Renewable Energy (beyond useful generation)	44%	41%	38%	35%	32%	29%	26%	24%	21%	18%	15%	12%

The cost of combined generation is calculated using the following formula:

$$\text{Cost}_{dispatchable} \times \text{Share}_{dispatchable} + \text{Cost}_{wind} \times (1 - \text{Share}_{dispatchable}) \times (1 + \text{RE}_{Curtailment_volume})$$

The results of these calculations are presented in the graph below.

Cost of Combined Generation at Varying Shares of Dispatchable Power in the Mix (KZT/kWh)



The graph shows that combining gas and wind power can reduce the electricity cost from around 40 to 30 KZT per kWh when gas generation operates in peak mode. The higher the share of renewables, the cheaper the combined kilowatt-hour becomes, thanks to lower specific gas-related costs. With coal, the situation is the opposite: the lower the share of renewables, the cheaper the electricity. This is because the fuel component for coal is lower than the cost of renewables. It is important to note that this is specific to Kazakhstan, where coal is relatively cheap. In China, where coal costs are around USD 100 per tonne, the combination of flexible coal and renewables is economically viable. Given limited gas availability and low specific CAPEX, the development of flexible coal generation is a key trend in China.

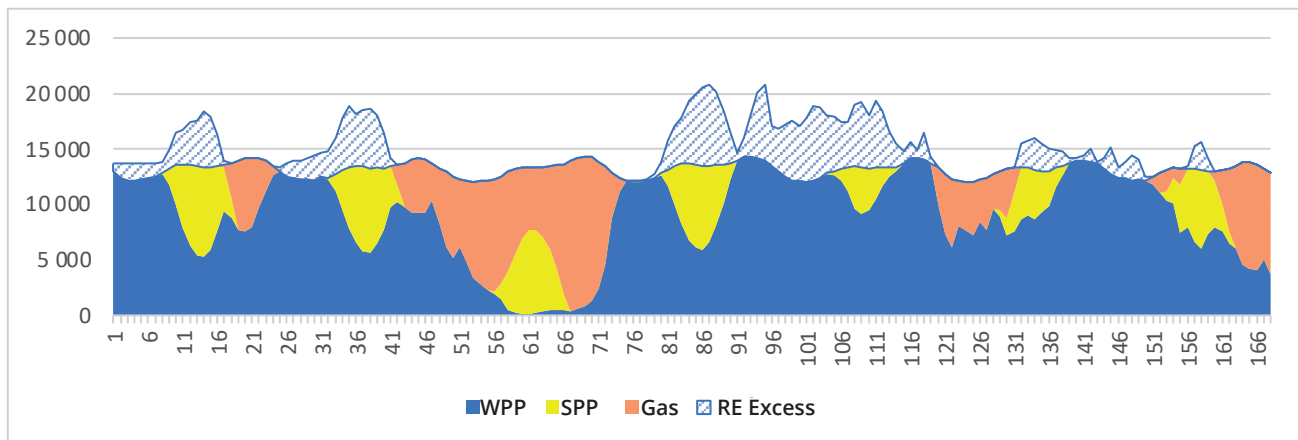
Including CO₂ costs in the calculation shows that emissions in a hybrid system with a high share of renewables and peaking gas capacity are significantly lower than in a system where thermal generation operates in baseload mode.

The illustration below presents the generation profile of a hybrid system with an excess of renewable capacity and peaking gas generation. Solar Plants are also integrated into the system, further lowering the tariff.

Key parameters of the modeled power system: Peak load of 16 GW, 10 GW of solar power plants, 24 GW of wind power, and 16 GW of gas-fired plants with 45% efficiency. The wind generation profile is based on average values from five sites with an average capacity factor of 37%. The capacity factor for solar power is 20%. Modeling results: renewable energy curtailment amounts to 18% beyond useful generation and is fully compensated to the investor. Gas-fired generation covers 29% of demand, operating at a capacity factor of 23%. The estimated electricity price is 32 KZT/kWh, excluding CO₂-related costs.

What should be done with the aging existing power plants?
Different types of existing plants require different solutions.

Electricity Generation by Source over One Week, MW



COAL-FIRED POWER PLANTS

Coal-fired plants with minimal tariffs (around 10–15 KZT per kWh) contribute to low system-wide electricity costs and should be kept in operation for as long as possible. Most of the equipment at these plants can be gradually replaced as part of capital repairs, ensuring relatively high operational reliability and maintaining component life within regulatory limits. At the same time, it is expected that the economic burden on coal-fired plants will increase over time, inevitably leading to higher tariffs and reduced competitiveness compared to other types of generation.

Key factors driving up the cost of coal-fired generation include:

- Mitigation of particulate matter emissions;
- Mitigation of gaseous emissions - sulfur oxides and nitrogen oxides;
- Restrictions on greenhouse gas emissions.

It is important to understand that these factors are manageable. If the government prioritizes keeping energy prices low, regulatory authorities have the ability to delay the implementation of these measures in order to maximize the prolonged use of economic benefits provided by inexpensive fuel. However, if these measures are implemented, the cost of electricity from existing coal-fired plants could increase two- to threefold. In such a scenario, converting these plants to gas, for example, by adding gas turbine units, may become economically viable. At the same time, this gas-fired generation should be accompanied by corresponding additional volumes of renewables, which, as shown earlier in this article, reduce the overall system costs.

Gas-Fired Power Plants

Gas-fired plants currently have relatively low tariffs due to gas price subsidies. Considering that most plants were built using the traditional steam cycle, their fuel efficiency is significantly lower than that of modern combined-cycle gas turbines (CCGTs), and their production costs and tariffs are notably higher than those of coal plants.

As the power system requires new capacity, it is advisable to transition existing gas plants to flexible operation modes while supporting new renewable capacity additions. This approach will significantly reduce absolute gas consumption and lower system

costs. It is also advisable to consider retrofitting steam power plants with gas turbine units to increase their capacity and improve efficiency.

Recommendations for Planning

To optimize energy costs and maintain the competitiveness of the economy, in my view, the following steps are necessary:

- Conduct energy planning using modern modeling tools such as PLEXOS. The use of such tools will help optimize the cost of electricity.
- Increase the involvement of the expert community in the planning and decision-making process regarding the future of the power system. It is important to consider not only the voices of energy professionals but also those of consumers, economists, and environmentalists, since decisions are planned for many decades ahead.
- Rely as much as possible on established competitive procedures when selecting new capacities. Kazakhstan's experience has already demonstrated the high effectiveness of auction mechanisms in reducing prices for renewables and new capacity.
- Establish mechanisms to support energy efficiency in the consumption of thermal energy. Extremely high specific consumption for heating and domestic hot water needs requires excessive CHP and heating network capacity, increasing losses. Careful management of thermal energy will help optimize the costs of creating and maintaining thermal capacity and bring Kazakhstan closer to fulfilling its decarbonization commitments.

KazNARU SUMMER SCHOOL: GREEN TRANSFORMATION OF THE ECONOMY AND SUSTAINABLE FUTURE THROUGH EDUCATION

Amid global climate challenges and rapid changes in the world labor market, universities play a key role in preparing the next generation of sustainable development leaders. In June 2025, the Kazakh National Agrarian Research University (KazNARU) organized a Summer School, which became an important educational platform for training young specialists in green economy, renewable energy, digital technologies, and sustainable ecotourism.

The school's slogan, “Learn, Practice, Transform”, reflects its strategic vision: integrating academic knowledge, practical skills, and current global trends in sustainable development.



Rafis Abazov,
Vice-Rector for International
Cooperation
Kazakh National Agrarian Research
University (KazNARU)





The event brought together over 450 students, young professionals, and faculty members from Central Asia, China, Turkey, Europe, and the Middle East. The program focused on the practical implementation of the United Nations Sustainable Development Goals (SDGs), with a special emphasis on climate, environmental issues, smart agriculture, and employment.

GREEN TRANSFORMATION AS A STRATEGIC DIRECTION

The Summer School opened with a panel discussion titled “Green Transformation of the Economy: Opportunities for Youth.” Representatives from international universities participated in the discussion.

The event featured a speech by the Chairman of the Board and Rector of the Kazakh National Agrarian Research University JSC (KazNARU), Akhymbek Kazhigulovich Kurishbayev.

“Green transformation is not just

a shift in technological paradigms, but a rethinking of the entire model of education and entrepreneurship, with a focus on inclusivity, biodiversity preservation, and long-term development,” the rector highlighted in his address.

It is worth noting that the Summer School program paid special attention to the development of renewable energy in rural regions, agro-ecological innovations, and sustainable water management; digitalization in sustainable resource management; ecological entrepreneurship; and the creation of an innovation ecosystem in agro- and ecotourism.

The practical component of the program included workshops, hackathons, and project sessions, where participants created practical startup ideas to tackle environmental and social challenges in Central Asia.

SUSTAINABLE ECOTOURISM PROJECTS DEVELOPED BY SUMMER SCHOOL PARTICIPANTS

One of the most prominent elements of the Summer School was the project module dedicated to sustainable ecotourism. Over ten days, a group of 35 students from Kazakhstan, Kyrgyzstan, Georgia, Uzbekistan, and Turkey, guided by international mentors, developed concepts for ecotourism routes in the foothills of the Ile Alatau and national parks around Almaty and the Almaty region.

The project included several key stages: analyzing territorial potential; assessing environmental impact; designing sustainable logistics; applying artificial intelligence and digital maps for navigation; and developing a marketing strategy and ESG reporting.

The project resulted in an innovative concept for the “Green Trail of the Great Silk Road” – a tourist route that integrates



“This project gave us a unique opportunity to apply the knowledge we gained in practice and truly feel part of the region’s sustainable development process”

scenic landscapes, cultural heritage, and modern digital technologies. Among the solutions proposed were the use of AR guides, QR code-based navigation, online eco-platforms, as well as the installation of solar panels along tourist routes in remote areas.

A distinctive feature of the project was the active involvement of local communities and the application of ecosystem-based principles, which allowed for consideration of both the population’s interests and the environmental constraints of the territory.

“This project gave us a unique opportunity to apply the knowledge we gained in practice and truly feel part of the region’s sustainable development process,” said G. Tsyra, a student from Georgia.

It is worth emphasizing that the projects developed by the students received wide recognition from representatives of international organizations.

For instance, Vlastimil Samek, Representative of the UN Department of

Global Communications and Head of the UN Information Centre in Kazakhstan, noted that youth initiatives in ecotourism have the potential to become a model of local sustainable development and to create new jobs in rural areas.

How can universities integrate the principles of the green economy into their curricula? What support tools are necessary for the development of youth eco-startups? What role does regional cooperation play in promoting green transformations? These are precisely the questions that the Summer School participants sought to address. At the same time, participants showcased their projects during the closing forum.

An important outcome of the forum was the proposal to establish a permanent “Living Laboratory” of sustainable development and ecotourism at KazNARU—an open platform for pilot projects, startups, and research conducted by students and young scientists.

The organization of the Summer School was made possible thanks to the active

participation of sponsors and partners. The programs and projects were successfully implemented with the support of the Almaty Tourism Bureau, as well as universities such as KBTU, Turan, and other educational institutions. Their contribution lay in valuable ideas, knowledge, and experience in entrepreneurship. Thanks to this support, participants had a unique opportunity to develop skills, exchange experiences, and establish professional contacts. We sincerely thank everyone who became part of this important educational event.

The program was further enriched by workshops, lectures, and practical sessions conducted by experts from various fields. Participants not only gained a solid theoretical foundation but also had the chance to apply their knowledge in practice by solving real-life cases. This created an atmosphere of collaboration, inspiration, and the drive to achieve new accomplishments.

“Participation in the Summer School was an excellent opportunity to establish inter-university collaboration and develop joint master’s programs in sustainable development,” commented a representative from one of the universities in Malaysia.

The KazNARU Summer School demonstrated that with the right educational approach, an interdisciplinary approach, and student involvement in real projects, it is possible to effectively cultivate ecological thinking, entrepreneurial skills, and leadership qualities in young people. Such events not only inspire but also lay the foundation for building sustainable communities oriented towards a “green future”.

At the same time, the Summer School served as a pilot platform for testing new formats: a Mini MBA in Eco-Entrepreneurship, ESG workshops, and simulation games on international climate diplomacy.

FUTURE PLANS AND EXPANSION OF COLLABORATION

“If we want to change the world, we need to start with education. And the Summer School is exactly the place where this is possible,” said Rafis Abazov, Vice-Rector for International Cooperation at KazNARU.

Indeed, in the context of climate

challenges and limited natural resources, there is a need for a new wave of leaders capable of thinking systemically, acting locally, and considering the global consequences of their decisions. The KazNARU Summer School clearly demonstrated that such leaders are already emerging among youth who are ready to take responsibility, propose innovative solutions, and work for the benefit of Kazakhstan, the region, and the entire planet.

In the future, the university plans to expand the program, launch an eco-startup accelerator, and integrate best practices in sustainable development into its academic and research activities. Focus will be placed

on developing alternative energy sources—namely solar, wind, and bioenergy—as central pillars of the transition to a low-carbon economy.

Furthermore, KazNARU intends to strengthen partnerships with industrial enterprises and businesses to jointly develop applied solutions, implement innovations, and provide students with access to real-world production experience.

Active involvement of international experts and organizations will help to broaden the scope of collaboration, facilitate the exchange of advanced knowledge, and enhance the university’s contribution to building a sustainable future for the region.



Engineers for the Energy Transition: KBTU Responds to the Renewable Energy Workforce Shortage

Over the past decade, the modern world has undergone fundamental changes in the way energy is produced, distributed, and consumed. The growing interest in renewable energy sources (RES) has long gone beyond environmental concerns. Today, the development of renewables is a strategic necessity for the sustainable development of the economy.

THE TRANSITION TO SUSTAINABLE ENERGY REQUIRES NEW TALENT

According to a report by the International Renewable Energy Agency (IRENA), the number of jobs in the renewable energy sector has shown steady growth over the last ten years, nearly doubling from approximately 7 million in 2012 to 13.7 million in 2022. This growth has been driven by the rapid development of solar, wind, hydro, and bioenergy around the world, as well as the expansion of supply chains, manufacturing capacity, and projects for the construction and operation of renewable energy facilities.



Beisenkhanov Nurzhan,
Dean of School of Materials Science
and Green Technologies



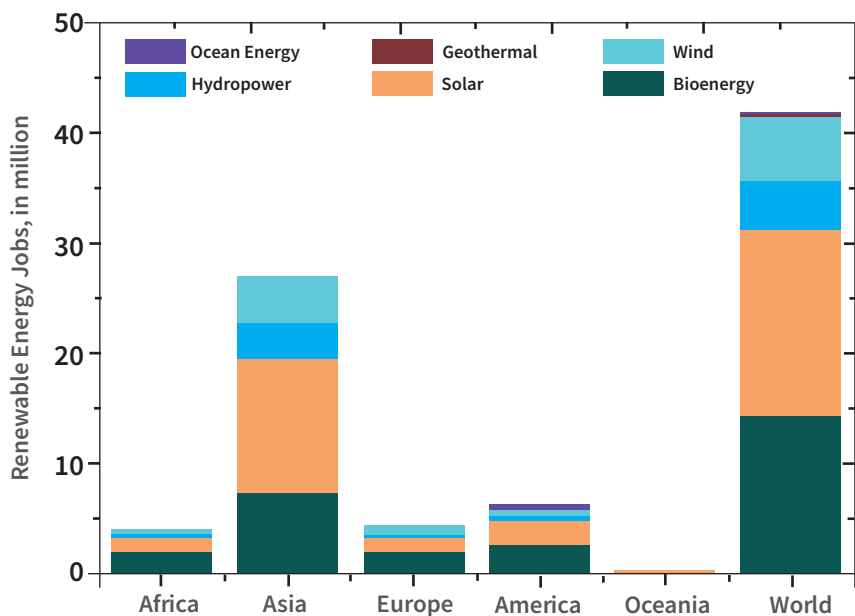
Sultanov Assanali,
Head of Laboratory of Alternative
Energy and Nanotechnology



Kazakhstan, the ninth largest country in the world by land area, possesses significant potential for solar, wind, and other green energy sources. The country is striving to reduce its carbon footprint, achieve energy independence, and develop a competitive green industry. However, none of these goals can be achieved without the systematic training of a new generation of qualified professionals.

The Kazakh-British Technical University (KBTU), as the country's leading engineering and technical university, is systematically building a science and education ecosystem aimed at training specialists in the field of renewable energy. A key role in this process is played by the School of Materials Science and Green Technologies (SMSaGT), which serves as a scientific

Figure 1 – Renewable Energy Jobs in 2050 under the Energy Transition Scenario, by Region (in millions)



Moreover, according to IRENA's projections, under a climate-resilient global energy transition scenario, the total number of jobs in the renewable energy sector could reach 42 million by 2050 (Figure 1). Solar and bioenergy are expected to contribute the most to job creation. Notably, more than 60% of all renewable energy jobs are projected to emerge in our region. These figures highlight not only the importance of renewables for the decarbonization of the global economy, but also their crucial role in creating new jobs, advancing green professions, and stimulating sustainable economic growth.

and experimental platform for undergraduate, master's, and PhD students.

KBTU'S SCHOOL OF MATERIALS SCIENCE AND GREEN TECHNOLOGIES: ENGINEERING FOR A NEW ERA

The School of Materials Science and Green Technologies (SMSaGT) was established on August 1, 2022, at the Kazakh-British Technical University, building on the foundation of the university's scientific and educational centers for alternative energy and nanotechnology, and the "Materials Science and Corrosion Challenges" unit. Today, in fulfilling its mission, SMSaGT actively draws on the scientific expertise of the Laboratory of Alternative Energy and Nanotechnology (LAEaN) and the Laboratory of Advanced Materials and Technologies (LAMaT). The school's primary focus is to train specialists capable of addressing current challenges in nanotechnology, materials science, and renewable energy.

The courses offered at SMSaGT follow an interdisciplinary approach. The bachelor's, master's, and PhD programs combine engineering and physics fundamentals with modern digital tools for modeling, analysis, and optimization. Significant emphasis is placed on sustainability, the life cycle of energy systems, and decarbonization policy.

SMSaGT distinguishes itself through a strong emphasis on research-driven education. From their very first year, students work under the guidance of professors and instructors on real scientific projects, conduct laboratory experiments, and contribute to the preparation of academic articles and conference presentations. Each academic year concludes with the defense of project work related to energy systems, renewable energy materials, or environmental technologies. SMSaGT maintains close ties with industrial partners

and international universities, enabling students to take part in internships abroad, engage in joint research initiatives, and become part of the global scientific community.

Shaping the engineering mindset of the future requires a unique educational environment. At SMSaGT, modern laboratories and experimental facilities are actively used to ensure a continuous link between theory and practice. Here, knowledge goes beyond theory, it is transformed into practical skills for real-world challenges.

LABORATORY OF ALTERNATIVE ENERGY AND NANOTECHNOLOGY: FROM CONCEPT TO EXPERIMENT

One of the key components of the "learning through research" system is the Laboratory of Alternative Energy and Nanotechnology. The laboratory was established at the Kazakh-British Technical University on May 2, 2011, under the leadership of Professor K. Kh. Nussupov, as a research platform for advancing cutting-edge developments in solar and wind energy, as well as functional nanomaterials. Today, the laboratory serves not only as a scientific hub but also as a true school of engineering practice. Its research spans a wide range of areas from the design of unique wind power systems to the development of multifunctional nanocoatings.

One of the main areas of focus at the laboratory is the development of solar cells with various architectures and their subsequent assembly into solar panels. The laboratory is equipped with a full production cycle for silicon-based solar panels. In recent years, the lab's researchers, in collaboration with colleagues from Nazarbayev University, have actively been working on the development of perovskite/silicon tandem solar cells, which is one of the most promising directions in modern photovoltaics. This collaboration between KBTU and Nazarbayev University fosters



Student Work Process at the Laboratory of Alternative Energy and Nanotechnology

the integration of scientific research with innovative technologies and enhances inter-university cooperation in the field of solar energy development in Kazakhstan.

The operating principle of tandem solar cells is based on the sequential stacking of two photoactive layers, each optimized to absorb a different portion of the solar spectrum. In conventional silicon solar cells, a significant share of high-energy (blue and

ultraviolet) photons is lost as heat, since silicon is most efficient in the near-infrared and visible ranges. Perovskites, on the other hand, offer the ability to precisely tune the bandgap, making them highly effective at capturing shorter-wavelength (high-energy) radiation.

In a tandem architecture, the top perovskite layer absorbs high-energy photons, while the bottom crystalline silicon layer captures the lower-energy photons that pass through the upper cell. This design significantly increases quantum efficiency and enables



Researchers and Students at KBTU's Laboratory of Alternative Energy and Nanotechnology

Figure 2 - Research Areas of the Laboratory of Alternative Energy and Nanotechnology

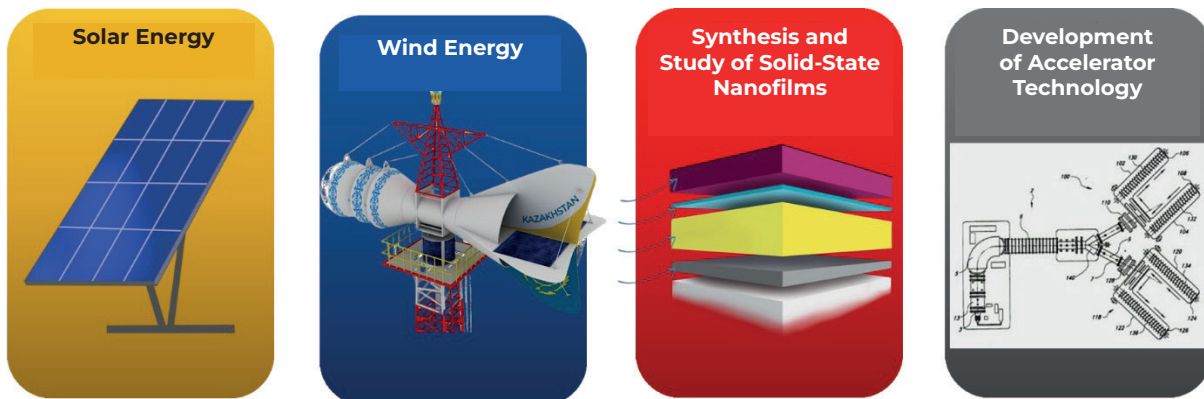
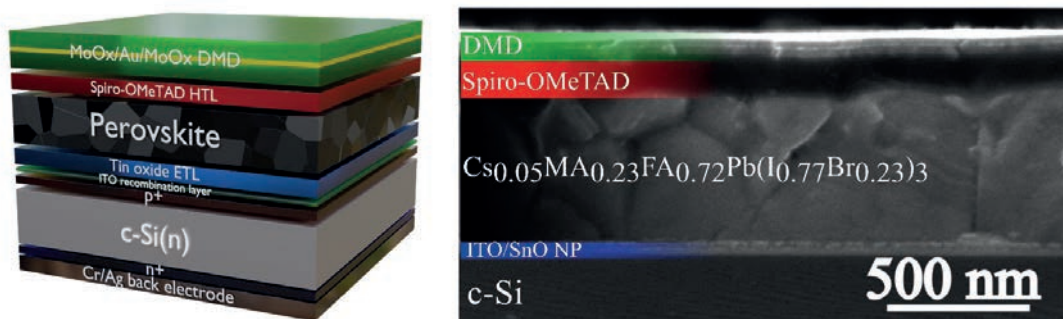


Figure 3 – Structure of a Perovskite/Silicon Tandem Solar Element



broader utilization of the solar spectrum, achieving a potential conversion efficiency of over 35%, surpassing the theoretical limit of traditional silicon cells (~29–30%). These and related challenges are the focus of the PhD dissertation of A.T.Sultanov, the head of the laboratory, as well as several master's theses and undergraduate research projects by young scientists and students.

Thus, faculty members, highly qualified specialists, and students collaborate in the development and advancement of cutting-edge photovoltaic technologies. However, the laboratory's work is not limited to theoretical and experimental research. One of its priorities is practice-oriented student training, which includes involvement in the operation and monitoring of functioning solar power plants. This hands-on approach allows young specialists not only to reinforce their academic knowledge, but also to gain valuable experience working with real-world energy infrastructure.

The Laboratory of Alternative Energy and Nanotechnology represents a unique scientific and educational environment where innovative developments in renewable energy are seamlessly integrated with the training of a new generation of engineers. Through the close integration of research, practice, and education, the laboratory plays a vital role in advancing sustainable energy technologies and building scientific capacity.

CONCLUSION: ENERGY BEGINS WITH PEOPLE

The transition to green energy is not only a matter of infrastructure. It is, above all, a matter of human capital. Universities play a key role in shaping the intellectual foundation of the future economy, laying the scientific and engineering groundwork for sustainable development.

The School of Materials Science and Green Technologies, together with its research laboratories, serves as a vital part of this system at KBTU, where education, science, and innovation converge. In the face of global challenges and climate uncertainty, this is where the engineers of the future are being trained—those who both understand why humanity needs energy and know how to create it for the common good using green technologies.

KAZAKHSTAN'S INTEGRATED GAS EMISSION TREATMENT SYSTEMS



Air pollution caused by the combustion of fossil fuels in industry and transportation remains one of the key drivers of chronic and oncological diseases, often leading to premature death and significant socio-economic losses.



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In Kazakhstan, approximately 75% of electricity is generated by burning coal, primarily at 37 combined heat and power (CHP) plants that rely on domestic fuel from the Ekibastuz, Karaganda, and other coal basins. The resulting emissions of SO₂, NO_x, CO₂, particulate matter, ash, heavy metals, and organic compounds contribute to smog formation, acid rain, and ozone layer depletion. Sulfur dioxide is particularly toxic and has a severe impact on the respiratory system.

At the national level, the government is considering converting CHP plants and industrial facilities to natural gas. While this does reduce emissions, it does not fully resolve the issue. For instance, CHP-2 in Almaty currently emits over 37,000 tons per year, and even after switching to gas, emissions would still remain at around 2,000 tons annually — with

conversion costs exceeding 300 billion tenge. Given the lower heating value of gas and rising energy prices, the transition is accompanied by increased tariff pressure on the population.

Thus, phasing out coal will require enormous investment and, in many cases, will be technically and economically challenging due to logistical and infrastructure constraints.

Meanwhile, coal remains the most accessible and strategically important resource: Kazakhstan ranks 8th in the world in proven reserves, with approximately 34 billion tons. This ensures long-term energy security and allows for the continued use of existing infrastructure.

However, as cities expand, CHP plants are increasingly located within urban areas, exacerbating both environmental and social issues. Relocating such facilities requires substantial investment, and increased distances

for heat and electricity transmission lead to higher end-user costs.

Under these circumstances, the most rational approach is not to abandon coal altogether, but to implement modern integrated gas cleaning systems capable of reducing emissions to levels comparable to those of green energy. This offers a realistic path toward reducing the harmful impact on public health while preserving the resilience of the national energy system.

And there is a solution. As part of a project for the commercialization of the Results of Scientific and/or Scientific-Technical Activities, co-financed by the Science Fund and Kazakh-British Technical University JSC, a production facility for Integrated Cleaning Systems (hereinafter ICS) has been established at the D.V. Sokolsky Institute of Fuel, Catalysis and Electrochemistry JSC (hereinafter referred to as “the Institute”). These systems are based on domestically produced catalytic converters for neutralizing toxic components of emissions from vehicles and industrial facilities, using a unique, proprietary, and patented technology.

Integrated gas cleaning enables the removal of both particulate matter and harmful gases from flue gases using a variety of methods: liquid absorption (absorption), solid material capture (adsorption), catalysis, and reagent treatment. At coal-fired CHP plants, the best results are achieved through a combination of wet scrubbing with

specialized filters and catalysts. Modern battery emulsifiers are particularly effective — compact units with no moving parts that provide efficient mixing of gas and reagent. However, after such treatment, additional processing (e.g., reagent-based) is often required to eliminate residual gases. In addition to cleaning, waste processing is also important. For example, dry ash can be reused in construction, which is not the case with wet ash. In Kazakhstan, existing systems often focus only on dust removal and do not address the full range of pollutants. The modular configuration is seen as the most effective solution, allowing for the use of multiple treatment technologies tailored to particular conditions.

As part of the development of the Integrated Cleaning System (ICS), an extensive set of studies was conducted, including theoretical calculations and experimental testing aimed at improving the efficiency of flue gas treatment. The design of the neutralizers was optimized to reduce gas-dynamic resistance, and catalysts based on platinum and 3D-metals (vanadium, cobalt) were developed, offering high thermal stability and regenerability. Active phases capable of removing up to 90% of NO_x were created, and the properties of aerogels were investigated as promising catalyst supports. Modules for absorption, catalysis, and adsorption were designed and calculated, including scrubber-emulsifiers and CO₂ adsorbers with NaX zeolite. The ICS system was implemented using a modular

Figure 1. Integrated Cleaning System



Figure 2. Pilot Testing at CHP-2, Almaty



approach, allowing it to be tailored to specific facilities — from large-scale CHP plants to mobile units. Balance and design calculations were carried out for gas flow rates of 500 m³/h, providing a foundation for scaling up and industrial implementation.

Catalytic blocks for neutralizing harmful components in flue gases are installed into industrial exhaust systems using patented universal mounting assemblies, and the designs of the multi-module ICS units are also protected by patents. In parallel a digital twin of the ICS is being developed as a virtual model that visualizes all stages of the purification process based on mathematical calculations. This system not only facilitates real-time monitoring and control but also enables equipment performance forecasting, efficiency optimization, and failure prevention. The use of digital twins in gas purification and CO₂ capture opens up new possibilities for optimizing industrial processes, reducing emissions, and achieving environmental sustainability.

The development of the ICS applied advanced global approaches similar to those used by Mitsubishi Power (Japan), taking into account experience gained during meetings held by our specialists. At the same time, a key principle was the adaptation of the technology using available local materials and engineering solutions.

The products of the country's only production facility, while matching the quality of foreign analogues, are designed for the purification of gaseous emissions from toxic and harmful components and make it possible to substitute expensive imported equipment.

The ICS consists of several independent stages, each differing in function, design, and operating principle. These stages can be configured based on the specifics of the industrial facility where the system is to be installed, the customer's requirements, and the desired level of purification, following a modular approach. The ICS can be used with any thermal equipment that generates energy through combustion, including in mobile configurations.

Each stage removes a specific set of harmful components from the emissions.

Carbon dioxide can be converted into a wide range of valuable compounds: methanol and dimethyl ether as alternative fuels; sulfonates and carbonates for the chemical industry; polycarbonates and polymers for the production of next-generation plastics; and can also be used in agrotechnologies to stimulate the growth of biomass and microalgae, followed by the production of biofuels and protein concentrates.

The full ICS configuration is designed to remove harmful components from gaseous emissions, including particulate matter, CO, NO, NO₂, C_xH_y, and SO₂.

Pilot testing of the ICS conducted at CHP-2 in Almaty demonstrated high efficiency and a high degree of purification.

The integration of a CO₂ capture module, which is currently being developed by Institute scientists using a sorbent produced through a unique, proprietary, patented technology involving ash, creates a unique opportunity to position coal as an environmentally safe resource and potentially redefine it as a "green" energy source. This opens up strategic prospects for the sustainable development of Kazakhstan's energy sector.

Carbon dioxide can be converted into a wide range of valuable compounds: methanol and dimethyl ether as alternative fuels; sulfonates and carbonates for the chemical industry; polycarbonates and polymers for the production of next-generation plastics; and can also be used in agrotechnologies to stimulate the growth of biomass and microalgae, followed by the production of biofuels and protein concentrates. The disposal of CO₂ through its transformation into valuable materials assigns economic value to emissions, effectively converting a waste stream into a resource. This approach enables not only carbon capture, but also the complete closure of the carbon cycle, integrating decarbonization into a circular economy and supporting the transition toward a carbon-neutral future.

As the domestic exhaust gas cleaning technology is scaled up, it is planned to undergo continuous modernization and automation aimed at further reducing operating costs and improving energy efficiency. This will both enhance the and stability of the cleaning process and enable real-time system control, which is especially important under variable operating conditions at industrial facilities.

Widespread implementation of the facility's products, saving trillions of tenge in public spending, will make it possible to nearly eliminate atmospheric pollution.

The solution to the main environmental problems is clear: the key measure is to ensure the installation of these domestic cleaning systems on ALL pollution sources and to prohibit the operation of equipment with malfunctioning purification systems.





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EU4SustainableCentralAsia: RENEWABLE ENERGY IN CENTRAL ASIA: NEW REGIONAL EFFORT TO STRENGTHEN EU-CENTRAL ASIA ENERGY COLLABORATION AND REGIONAL INTEGRATION

Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (The German federal enterprise for international cooperation), EU4SustainableCentralAsia project



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Central Asia has a unique opportunity to build a green energy power system through an integrated regional approach based on variable renewable energy. Though each country – Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan – faces its own challenges, they share common needs, resources, and a long history of interdependence.



The region has a population of over 80 million people, with unique energy resources that are unevenly distributed. In particular, in Turkmenistan, Uzbekistan and Kazakhstan there are large reserves of fossil fuels, while Tajikistan and Kyrgyzstan have unique reserves of hydro resources. Currently, Uzbekistan and Kazakhstan are the driving force in the region in promoting solar and wind, setting the pace for renewable energy adoption. Meanwhile, Tajikistan and Kyrgyzstan hold the potential to become the region's balancing hubs, leveraging their vast hydroelectric resources to ensure stability and support the growth of variable renewable energy.

The energy transition here is far more than an environmental imperative – it is equally an economic, social, and geopolitical transformation. The region experiences climate impacts more acutely than many parts of Europe,

grappling with extreme weather and water scarcity to seasonal blackouts. Expanding solar, wind power and energy storage capacity can provide critical electricity during droughts and could potentially decrease the demand for electricity from hydropower and mitigating climate risks. Beyond just resilience, this renewable energy transition will also contribute to economic growth and new employment opportunities.

To address environmental and socio-economic challenges, contributing to a sustainable future for Kazakhstan and Central Asia through the promotion of renewable energy integration, Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH (the German federal enterprise for international cooperation) is implementing a regional project, the EU4SustainableCentralAsia: Renewable Energy in Central Asia (EURECA).

Project name	EU4SustainableCentralAsia: Renewable Energy in Central Asia
Commissioned by	German Federal Ministry for Economic Cooperation and Development (BMZ) and the European Union
Implemented by	Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH
Project region	Kazakhstan, Kyrgyz Republic, Tajikistan, Turkmenistan, Uzbekistan
Duration	December 2024 – November 2028



ABOUT THE PROJECT

EURECA supports policymakers, power grid operators, and government agencies in all five Central Asian countries to create the right conditions for developing and integrating renewable energy sources. Commissioned by the German Federal Ministry for Economic Cooperation and Development and co-funded by the European Union, the project provides a platform for cross-border collaboration and targeted national-level assistance. It aligns with individual country priorities while advancing shared goals for climate action, water management, and energy transition.

“A key goal of the EURECA project is to optimize coordination, dispatching and management between energy companies in Central Asia. Just as important is fostering regional exchange and partnerships – creating spaces for public dialogue and encouraging the free flow of knowledge between our political partners, energy sector institutions, universities, researchers and private sector in Central Asia”.

The project is both an expansion of GIZ’s substantial green portfolio — spanning climate action, water management, hydrogen development, and energy efficiency — and a continuation of Germany’s Strategic Partnership with Central Asia through its Green Central Asia initiative. By promoting regional stability and reducing the impacts of climate change on glaciers and other critical resources such as water, land, and soil, EURECA contributes to improved food security, reliable water access, and healthier habitats for people, plants, and wildlife.

At the same time, the project marks a proactive step in fulfilling the European Union’s commitment to Central Asia. As

part of the EU’s Global Gateway and Team Europe Initiative, it reflects a shared commitment to a strategic partnership based on shared values and mutual interests. “The EU remains a reliable, forward-looking partner for Central Asia, investing in its long-term sustainable development for mutual, long-lasting benefit. Consistency, predictability and ambition will continue to drive our joint efforts,” said António Costa, President of the European Council, following the first EU-Central Asia Summit in Samarkand.

FIRST EU-CENTRAL ASIA SUMMIT, 4 APRIL 2025

On 4 April 2025, the first Central Asia - European Union Summit was held in Samarkand. It was chaired by the President of the Republic of Uzbekistan Shavkat Mirziyoyev. The EU was represented by the President of the European Council António Costa and the President of the European Commission Ursula von der Leyen. Together with President Mirziyoyev, Central Asian countries were represented by the President of the Republic of Kazakhstan Kassym-Jomart Tokayev, the President of the Kyrgyz Republic Sadyr Japarov, the President of the Republic of Tajikistan Emomali Rahmon and the President of Turkmenistan Serdar Berdimuhamedov.

Against the backdrop of increasing high-level bilateral engagements over the past years and a rapidly evolving multilateral- and regional agenda, the EU and Central Asia leaders agreed to elevate relations between the two regions by establishing a strategic partnership.

“Significant efforts have been made to strengthen regional cooperation within Central Asia, overcoming challenges and fostering closer partnerships to ensure prosperity, sustainable

development and to accelerate the energy transition and decarbonisation, strengthening stability, security, and good neighbourly relations. In this respect, the EU welcomed strengthened regional cooperation through regular Consultative Meetings of the Heads of State of Central Asia. The EU expressed its readiness to support ongoing and future actions in support of further regional integration...”

FROM PLANNING TO ACTION

During 2024-2025, the EURECA team engaged with key partners across the region through interviews and consultations. These in-depth discussions with national and regional stakeholders helped shape a clear consensus on the project’s main objectives and activities.

EURECA aims to create the right environment for renewable energy growth – supporting partners in crafting effective policies, adopting digital tools, and enhancing grid management practices. The project will also aim to continue coordinating among donors, builds on previous efforts, and ensure continuity in the region’s energy transition journey.

Anticipated activities will support the region in planning and managing more flexible energy systems, while helping partners attract investments in variable renewables.

LEARNING AND COLLABORATION IN EUROPE

In October 2025, the EURECA project will host a regional study tour to Belgium for delegations from Central Asia. The group includes key decision-makers shaping energy policies and regulatory frameworks, along with the representatives from the regional Coordinating Dispatch Center.

While the agenda includes many meetings with Belgian counterparts, the tour also offers invaluable opportunities for participants from Central Asia to connect, exchange insights, and spark fresh ideas among themselves.

The tour will showcase Europe’s experience in integrating variable renewable energy - covering enabling policies, financing tools to flexible grids, storage technologies, digital systems, and institutional cooperation models.

By the end of the tour, participants aim to align on shared priorities, identify concrete steps to boost cross-border electricity trade, and open



Significant progress has been made in strengthening regional cooperation in Central Asia, addressing existing challenges, and fostering closer partnerships to ensure prosperity, sustainable development, an accelerated energy transition and decarbonisation, as well as enhanced stability, security, and good-neighbourly relations. In this context, the EU welcomed the deepening of regional cooperation through regular Consultative Meetings of the Heads of State of Central Asia. The EU also reaffirmed its readiness to support current and future initiatives aimed at advancing regional integration.



new avenues for regional collaboration.

CENTRAL ASIA AT THE GLOBAL GATEWAY FORUM 2025

At the same time, Central Asian ministers and deputy ministers will travel to Brussels to take part in the second Global Gateway Forum during 9–10th October 2025.

Building on the success of its inaugural event in 2023, the Forum will bring together high-level representatives from governments, financial institutions, the private sector, and civil society to explore ways to scale up sustainable investment partnerships amid a complex geopolitical and economic landscape.

Confirmed speakers include Ursula von der Leyen, President of the European Commission; Jozef Sikela, European Commissioner for International Partnerships; Dubravka Šuica, European Commissioner for the Mediterranean; and Marta Kos, European Commissioner for Enlargement — underscoring the EU’s deep commitment to engaging with partner regions on shared strategic priorities.

Launched in 2021 Global Gateway is the European Union’s flagship strategy to boost smart, clean, and secure connections across digital, energy, and transport sectors, while strengthening health, education, and research systems worldwide. With ambitions to mobilise up to €300 billion in investments through a Team Europe approach, it combines the resources and expertise of EU institutions, Member States, and development banks to leverage private sector capital.

Rooted in democratic values, transparency, and high environmental and social standards, Global Gateway seeks to close the global investment gap by delivering quality infrastructure and fostering equal partnerships.

For Central Asia, participation in the Forum offers a platform to strengthen ties with the EU, explore transformative projects, and align regional priorities with the broader global agenda for sustainable and resilient growth.

Engagements like these are vital for raising the region’s profile on the world stage, ensuring that Central Asia’s priorities are reflected in global decisions on sustainable infrastructure, energy transition, and climate resilience. This is one of the opportunities EURECA aims to present to the partners to help unlock new global partnerships, attract investment, and accelerate the implementation of projects that deliver lasting benefits across the region.

Current Status, Challenges and Opportunities for China-Central Asia Renewable Energy Investment and Financing Cooperation: A Case Study of Kazakhstan and Uzbekistan



Amid the escalating global climate crisis, accelerating clean energy transition has become a widely shared international priority. Over the past decades, the landscape of global energy investment has shifted dramatically, with clean energy investments continuing to outpace fossil fuels. According to the International Energy Agency (IEA) global energy investment is set to rise to USD 3.3 trillion in 2025, with twice as much investment in clean energy as in fossil fuels. Despite this encouraging trend, two major imbalances persist. First, developing countries remain largely on the margins of global climate finance. In 2023, only 15% of global renewable energy investment flowed to 120 developing countries, with Sub-Saharan Africa receiving less than 1.5%. Second, investment in power grids lags significantly behind the rapid deployment of solar and wind energy, creating critical bottlenecks for integrating renewable energy into energy systems.



Developing countries play a critical role in this transition, yet fully unlocking their renewable energy potential requires strong international support in financing, technology, and capacity building. Kazakhstan and Uzbekistan, two key developing economies in Central Asia, are experiencing rapid urbanization and industrialization while facing significant climate vulnerability. Promoting a green and just energy transition in these countries is essential—not only to curb greenhouse gas emissions and reduce fossil fuel dependence, but also to drive green economic growth and advance more inclusive, sustainable socio-economic development. Nevertheless, both countries face considerable challenges in meeting their low-carbon transition goals. These include high domestic financing costs, aging grid infrastructure, policy and regulatory uncertainties, underdeveloped market mechanisms, and a shortage of skilled professionals.





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In recent years, China has deepened green energy cooperation with Kazakhstan and Uzbekistan. Under the framework of the Belt and Road Initiative, China and the two countries have established intergovernmental strategic alignment mechanisms and signed several bilateral agreements covering renewable energy cooperation. Multilateral platforms such as the Shanghai Cooperation Organization (SCO), China–Central Asia Summit, and CAREC have further facilitated policy dialogue, technical exchange, and financial coordination. Meanwhile, Chinese policy banks, commercial lenders, and green tech firms are expanding their presence in Central

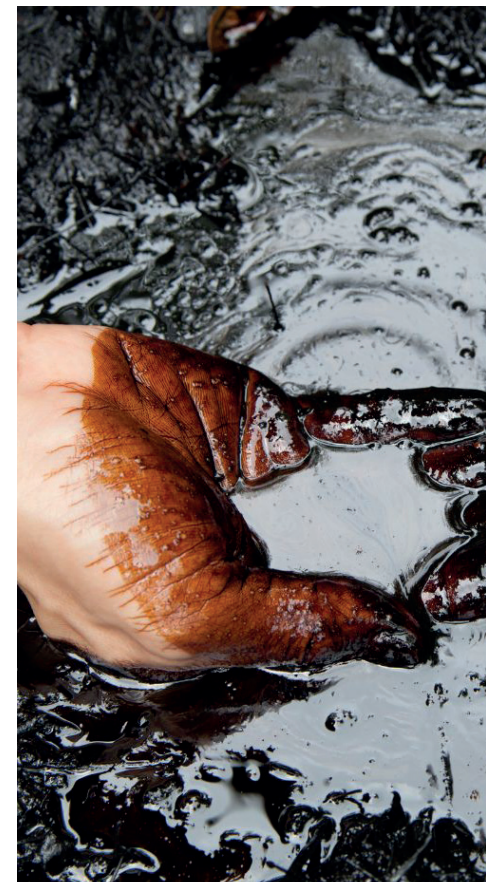
Asia, boosting investment and technology transfer to support the region's low-carbon transition.

As demand for renewable energy and green finance continues to grow in both countries, there is an urgent need to refine and adapt China's investment and financing models to better align with local market dynamics and project realities. Drawing on case studies of Kazakhstan and Uzbekistan, this research examines the key challenges and opportunities in China's renewable energy engagement and offers targeted policy recommendations to strengthen China–Central Asia cooperation in the sector.

OVERVIEW OF ENERGY TRANSITION IN KAZAKHSTAN



Energy structure: In Kazakhstan, the primary energy mix relies heavily on fossil fuels, characterized by high carbon intensity and significant export dependence. In 2022, coal accounted for 50.5% of the country's total primary energy supply, while oil and natural gas each contributed approximately 25%, and hydropower made up 1.1%. The energy sector is responsible for roughly 85% of its total carbon emissions, with electricity and heating systems alone contributing over half of the CO₂ output. Kazakhstan's carbon intensity per unit of GDP is about 70% higher than the global average. Export dependency is also significant—over 54% of energy production is exported, and oil and gas exports contribute around 20% of GDP. In 2023, the final energy consumption mix was led by petroleum products (33.5%), followed by coal (19.4%), natural gas (16.7%), thermal energy (15.3%), and electricity (15.0%), highlighting considerable potential for greater electrification. End-use energy consumption was concentrated in the residential (35.7%), industrial (26.4%), and transport (23.2%) sectors.



01

ENERGY STRUCTURE

02

POWER
STRUCTURE

Power structure Kazakhstan's power sector remains heavily dependent on fossil fuels, with around 70% of its electricity coming from aging coal-fired plants. While the energy mix has historically been dominated by thermal and hydropower, it is now gradually diversifying, with non-hydro renewable energy steadily expanding-though its share remains relatively

small. As of early 2024, the country operates 222 power plants with a total installed capacity of approximately 24.6 GW. Thermal power constitutes approximately 78% (19.2 GW), followed by wind power at 5.7% (1.4 GW), solar PV at 4.9% (1.2 GW) and hydropower at 11.4% (2.8 GW).



03

GRID, ENERGY STORAGE
AND RENEWABLE
ENERGY EQUIPMENT
MANUFACTURING

Grid, Energy storage and renewable energy equipment manufacturing: Kazakhstan's power grid consists of interconnected northern and southern zones linked by three 500 kV transmission lines, along with an isolated western zone. Due to uneven distribution of energy resources and load centers, there is a clear mismatch between regional supply and demand, placing pressure on cross-regional power dispatch. The grid also suffers from high transmission losses (around 8%) and limited peak-shaving flexibility. Energy storage remains in the early stages of development, limited to small-scale pilot and demonstration projects. Large-scale, utility-grade storage systems have yet to be deployed, and the country lacks a mature regulatory framework and technical standards to support their rollout. Kazakhstan's renewable energy equipment manufacturing industry is still nascent, with an underdeveloped supply chain. Most wind and solar components rely heavily on imported technologies and equipment, reflecting limited domestic production capacity.



NDCs and RE targets Kazakhstan has committed to unconditionally reducing greenhouse gas emissions by 15% from the emissions of 1990 by 2030, with a potential reduction of up to 25% contingent on international support. To support its climate ambitions, Kazakhstan aims to increase the share of renewable energy in power generation

04

NDCS AND RE TARGETS

to 6% by 2025, further raise it to 15% by 2030, and achieve 50% from renewable and alternative energy sources by 2050. The country has already surpassed its 2025 target ahead of schedule, with renewable energy accounting for 6.67% of total power generation in the first nine months of 2024.

OVERVIEW OF ENERGY TRANSITION IN UZBEKISTAN



Energy structure: Uzbekistan's primary energy production remains heavily reliant on fossil fuels, with natural gas accounting for 88% of total output in 2022, followed by crude oil (6.8%), coal (3.9%), and hydropower (1.2%). Wind and solar energy have yet to reach large-scale deployment. Fossil fuels continue to serve as a cornerstone of the national economy, with the oil, gas, and related sectors contributing around 16% to

01

ENERGY STRUCTURE

GDP in 2020. However, the sector faces growing challenges. Declining production—driven by lagging exploration, aging infrastructure, and depleted reserves—has been compounded by rising domestic energy demand and regional geopolitical pressures. As a result, Uzbekistan has gradually shifted from being a net energy exporter to a net importer, underscoring the urgency of accelerating its energy transition and diversifying its energy mix.



02

POWER STRUCTURE

Power structure: Uzbekistan's power sector is predominantly fueled by natural gas, which supplied approximately 82% of electricity generation in 2022. Renewable energy accounted for around 10% of the mix, with hydropower contributing more than

90% of that share. Several large-scale solar PV projects are scheduled to come online around 2024, which is expected to significantly increase the share of renewables in the country's power generation.



03

GRID AND ENERGY STORAGE

Grid and energy storage: Uzbekistan's power system is highly centralized and suffers from severe infrastructure aging. Over 60% of equipment across transmission lines, distribution networks, substations, and transformers has exceeded its designed operational lifespan. This deterioration contributes to significant technical losses—2.72% in transmission and 12.47% in distribution—undermining grid reliability, operational efficiency, and the system's ability to accommodate variable renewable energy. To address these challenges and support renewable energy integration, energy storage deployment has emerged as a strategic priority in Uzbekistan's energy transition. However, the sector remains in its infancy and is largely dependent on imported technologies and equipment.

04

NDCS AND RE TARGETS

Uzbekistan updated its NDC in 2021, aiming to cut GHG emissions per unit of GDP by 36% from 2010 levels by 2030. To support its climate ambitions, the country aims to increase the total installed capacity of solar and wind power to 8 GW by 2026 and further expand to 27 GW by 2030, with these sources accounting for over 40% of total power generation. As of 2023, Uzbekistan's total installed capacity of renewable energy reached approximately 2.7 GW, representing 15% of the country's total, with hydropower accounting for 91% and solar power 9%.

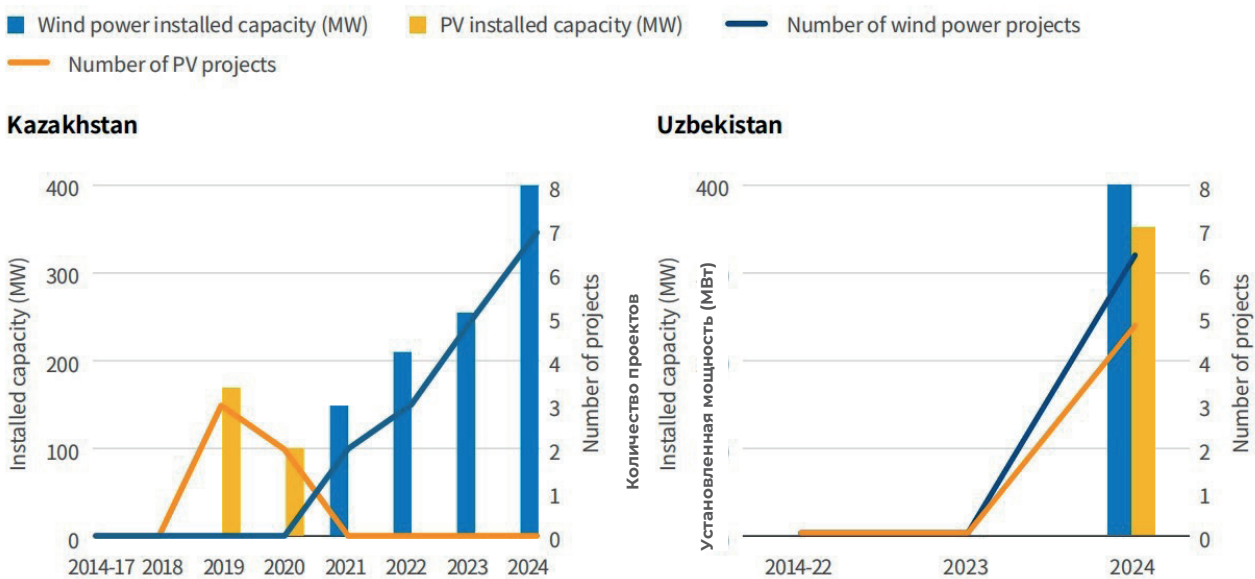
OVERVIEW OF RENEWABLE ENERGY INVESTMENT AND FINANCING COOPERATION BETWEEN CHINA AND CENTRAL ASIA

China is one of the largest trading partners and sources of foreign investment in Central Asia. Under the strategic alignment between governments and multilateral cooperation mechanisms, such as the China-Central Asia Summit, the Shanghai Cooperation Organization, and the Central Asia Regional Economic Cooperation (CAREC), countries in the region have identified clear cooperation goals, priorities, and frameworks in the renewable energy sector. Under the framework of the Belt and Road Initiative (BRI), China has upheld the principles of extensive consultation, joint contribution, and shared benefits, actively engaging in the investment and financing of renewable energy projects in Kazakhstan and Uzbekistan. This has led to the formation of a diversified financing ecosystem guided by government cooperation and driven by market-based capital. Chinese companies have evolved from early-stage roles focused on equipment exports and EPC contracting to engaging in greenfield investments and mergers and acquisitions. Financing models have also diversified beyond traditional bank loans, incorporating innovative approaches such as BRI green bonds, non-recourse project financing backed

by Sinosure export buyer's credit, commercial bank-led lending with Sinosure credit enhancement, multilateral syndicated loans, and offshore treasury centers of state-owned enterprises. These innovations have helped reduce project risks and capital costs. The range of participating actors has also expanded. In addition to large state-owned power companies, several technologically advanced and operationally agile private firms have become actively involved in solar, wind, energy storage, and smart grid projects, injecting sustained momentum into the region's green energy transition.

According to GreenovationHub's analysis of publicly available data, between 2014 and 2024, Chinese companies participated in 29 solar and wind power projects—either under construction or already in operation—in Kazakhstan and Uzbekistan through greenfield investments and acquisitions, with a total installed capacity of approximately 4,120 MW. In Kazakhstan, private enterprises dominate solar and wind development, while in Uzbekistan, state-owned companies hold a clear lead in both project count and capacity. Geographically, Chinese companies' total installed and under-construction capacity is estimated at around 1,300 MW in Kazakhstan and 2,820 MW in Uzbekistan.

Fig. 1 and Fig. 2 – Chinese enterprises' investment in wind and PV projects in Kazakhstan and Uzbekistan (2014–2024)



Source: Compiled by Greenovation Hub based on publicly available data

Table 1. Chinese enterprises' renewable energy investments in Kazakhstan and Uzbekistan

Country	Project Name	Type	Investor	Investment Model
Kazakhstan	Zhanatas 100 MW Wind Power Project	Wind power	China Power International Holding Limited (CPIH) (80% equity) Visor International DMCC (20% equity)	Greenfield investment (by establishing joint ventures)
Kazakhstan	Shokpar 100 MW Wind Power Project	Wind power	CPIH (63% equity) Visor International DMCC (37% equity)	CPIH first established a joint venture with Visor through greenfield investment and then completed the transfer of controlling interest via M&A.
Kazakhstan	Arkalyk 50 MW Wind Power Project	Wind power	CPIH Visor International DMCC	Greenfield investment (by establishing joint ventures)
Kazakhstan	Borey 100 MW Wind Power Project	Wind power	CPIH	M&A
Kazakhstan	Dostyk 50 MW Wind Power Project	Wind power	SUNGROW transferred 100% equity to CPIH	SUNGROW participated in the project under EPC+F model. Upon completion, CPIH acquired 100% ownership through M&A.
Kazakhstan	Energo Trust 50 MW Wind Power Project	Wind power	CPIH	M&A
Kazakhstan	Sofievskaya 40 MW Wind Power Project	Wind power	CPIH	M&A
Kazakhstan	Arkalyk 15 MW Wind Power Project	Wind power	CPIH	M&A
Kazakhstan	Jasil Jel 15 MW Wind Power Project	Wind power	CPIH	SUNGROW participated in the project under EPC+F model. Upon completion, China Power International Holding Limited acquired 100% ownership through M&A.
Kazakhstan	Shelek 60 MW Wind Power Project	Wind power	POWERCHINA (75%) Samruk-Energy (25%)	Greenfield investment (establishing joint ventures)
Kazakhstan	Ybyrai 50 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Kazakhstan	Abay 100 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Kazakhstan	Abay 50 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Kazakhstan	Mezgilder Qushteri 100 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Kazakhstan	Sarkylmas Kuat 50 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Kazakhstan	Damen Shuak 50 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Kazakhstan	Next Green Energy 50 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Kazakhstan	Kapchagay 100 MW PV Project	Photovoltaics	Universal Energy	Greenfield investment

Country	Project Name	Type	Investor	Investment Model
Kazakhstan	Zhangiz 30 MW PV Project	Photovoltaics	Universal Energy	Greenfield investment
Kazakhstan	Kaskelen 50 MW PV Project	Photovoltaics	Universal Energy	Greenfield investment
Kazakhstan	Zhangiz 30 MW PV Project	Photovoltaics	Universal Energy	Greenfield investment
Kazakhstan	Chulakkurgan 50 MW PV Project	Photovoltaics	CPIH	Risen Energy developed the project under EPC+F model. Upon completion, CPIH acquired 100% ownership through M&A.
Kazakhstan	Gulshat 40 MW PV Project	Photovoltaics	CPIH	Risen Energy developed the project under EPC+F model. Upon completion, CPIH acquired 100% ownership through M&A.
Uzbekistan	Peak Wind Alpha 250 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Uzbekistan	Peak Wind Beta 250 MW Wind Power Project	Wind power	Universal Energy	Greenfield investment
Uzbekistan	Bash 500 MW Wind Power Project	Wind power	China Southern Power Grid (35%) ACWA (65%)	M&A
Uzbekistan	Dzhankeldy 500 MW Wind Power Project	Wind power	China Southern Power Grid (35%) ACWA (65%)	M&A



Country	Project Name	Type	Investor	Investment Model
Uzbekistan	QashKadaryo 500 MW PV Project	Photovoltaics	China Gezhouba Group	Greenfield investment
Uzbekistan	Bukhara 500 MW PV Project	Photovoltaics	China Gezhouba Group	Greenfield investment
Uzbekistan	Buka 320 MW PV Project	Photovoltaics	China Datang Overseas Investment	Greenfield investment
Uzbekistan	Angren District Rochi 150 MW/300 MWh Energy Storage Project	Electrochemical energy storage	China Gezhouba Group	Greenfield investment
Uzbekistan	Fergana Oz 150 MW/300 MWh Energy Storage Project	Electrochemical energy storage	China Gezhouba Group	Greenfield investment
Uzbekistan	Chirchik 100 MW/200 MWh Energy Storage Project	Electrochemical energy storage	China Gezhouba Group	Greenfield investment
Uzbekistan	Adolat 100 MW/200 MWh Energy Storage Project	Electrochemical energy storage	China Gezhouba Group	Greenfield investment
Uzbekistan	Navoiy Hybrid Project (300 MW PV solar, 300 MW wind power, and 150 MW/300 MWh energy storage)	Wind-Solar-Storage Hybrid Project	China Gezhouba Group	Greenfield investment

Compiled by Greenovation Hub based on publicly available information

Table 2. Chinese enterprises' renewable energy investments in Kazakhstan and Uzbekistan

Type	Financing Institution
National development bank	 国家开发银行 CHINA DEVELOPMENT BANK
Policy bank	 中国进出口银行 THE EXPORT-IMPORT BANK OF CHINA
Policy bank	 中国出口信用保险公司 CHINA EXPORT & CREDIT INSURANCE CORPORATION
Commercial bank	  中国银行 BANK OF CHINA  中国建设银行 CHINA CONSTRUCTION BANK  中国民生银行 CHINA MINSHENG BANK
Multilateral development bank and international financial institution	 European Bank for Reconstruction and Development  AIB ASIAN INFRASTRUCTURE INVESTMENT BANK  ADB ASIAN DEVELOPMENT BANK  GCF GREEN CLIMATE FUND
Host country's state development bank	 Development Bank of Kazakhstan

Compiled by Greenovation Hub from publicly available information

Table 3. Key financing models of Chinese financial institutions for wind and PV projects in Kazakhstan and Uzbekistan (2014-2024)

Financing Model	Key Characteristics	Project Cases
Non-recourse project financing backed by Sinosure's export buyer credit insurance	<ul style="list-style-type: none"> · Repayment solely relies on expected project cash flows and asset value, without requiring additional investor guarantees · Sinosure provides up to 95% coverage for political and commercial risks · RMB used as settlement and financing currency 	<ol style="list-style-type: none"> 1. The 250 MW wind power project in Kazakhstan, invested by Universal Energy 2. QashKadaryo 500 MW & Bukhara 500 MW PV Projects in Uzbekistan, invested by China Gezhouba Group
Commercial bank-led lending with Sinosure credit enhancement	<ul style="list-style-type: none"> · Medium-to long-term green financing with low interest rate · Dual-currency financing services (RMB + USD) · Use of offshore institutions' domestic foreign exchange accounts (NRA accounts) 	Dostyk 50 MW Wind Power Project in Kazakhstan, invested by SUNGROW
Multilateral syndicated loans	<ul style="list-style-type: none"> · Blended currency financing (USD + local currency) · Limited-recourse project financing combined with shareholder bridge loans 	Zhanatas 100 MW Wind Power Project in Kazakhstan, invested by CPIH
Issuance of green bonds	<ul style="list-style-type: none"> · Onshore issuance of RMB-denominated bonds to support refinancing and acquisitions of overseas projects · Strong creditworthiness and green ratings · Significantly reduced financing costs 	CPIH issued two tranches of green panda bonds (February 2023 and November 2023, respectively) to finance the construction, operation, M&A activities, and loan repayments for the following renewable energy projects: Gulshat 40 MW Project; Chulakkurgan 50 MW PV Project; Shokpar 100 MW Project; Borey 100 MW Project; Energo Trust 50 MW Project; Sofievskaya 40 MW Project; Arkalyk 15 MW Project; and Arkalyk 50 MW Wind Power Project.
Financing by local financial institutions in host countries	Preferential loan	Kapchagay 100 MW Project in Kazakhstan invested in by Universal Energy
Offshore treasury centers of Chinese state-owned enterprises	By establishing a globalized and centralized financial resource management system, this model optimizes capital utilization, reduces financing costs, and minimizes cross-border guarantee requirements.	China Energy Engineering Corporation (CEEC)'s offshore treasury center has signed a USD 100 million loan agreement and completed the first disbursement of USD 60 million to support its subsidiaries' PV and energy storage projects in Uzbekistan.

Compiled by Greenovation Hub based on publicly available information



CHALLENGES AND OPPORTUNITIES IN STRENGTHENING CHINA-CENTRAL ASIA RENEWABLE ENERGY INVESTMENT AND FINANCING COOPERATION

• Challenges:

1. Heavy Reliance on Indirect Financing. China's renewable energy investment in Kazakhstan and Uzbekistan is still dominated by indirect financing channels. Direct financing and capital market instruments have yet to scale up, with limited application

of innovative tools such as green bonds. Fund-based financing models remain underutilized, and the participation of long-term institutional investors is insufficient, constraining both project expansion and capital recovery efficiency.

2. Underdeveloped Green Financial Products and Services. The current green finance system lacks diversity and innovation. Most tools are still concentrated in traditional instruments such as buyer's credit, bank

loans, export credit insurance, and guarantees. There is a gap in adopting internationally aligned instruments, such as sustainability-linked loans (SLLs), blended finance mechanisms, and risk-sharing tools for large-scale green projects. Furthermore, traditional tools have yet to be fully “greened”—with limited use of climate-adaptive debt clauses, green guarantees, or climate-focused insurance products.

3. High Exchange Rate Risk and Limited Hedging Mechanisms. Chinese enterprises face considerable foreign exchange risk driven by rising U.S. dollar financing costs, underdeveloped local currency derivatives markets, and limited cross-border use of the RMB. The absence of mature hedging instruments undermines return expectations and heightens financial uncertainty.

4. Limited Cooperation with Multilateral Development Banks. Chinese enterprises mainly adopt the EPC+F model for their overseas projects, and their cooperation with multilateral development banks is limited. This approach results in high financing costs, heavy asset burdens, and substantial cash flow pressures. As international renewable energy players increase their presence in Central Asia, competition has intensified, electricity prices are falling, and Chinese enterprises are increasingly disadvantaged due to higher capital costs and less flexible financing models.

5. Policy and Regulatory Uncertainty. Both Kazakhstan and Uzbekistan lack integrated energy and power development plans aligned with their Nationally Determined Contributions (NDCs) and the Paris Agreement. Further, inconsistent policies, weak regulatory frameworks, and limited legal safeguards reduce the predictability of project development and undermine financing feasibility.

6. Unfavorable Market Mechanisms for Clean Energy. The current market environment in both countries does not yet provide a level playing field for clean energy. Distorted electricity pricing, substantial fossil fuel subsidies, serious cross-subsidization, and poorly designed revenue mechanisms all weaken the investment appeal of renewables and prevent full realization of their system value.

7. Grid Infrastructure Constraints. Ageing grid infrastructure, high technical losses, and limited peak-shaving capabilities in both Kazakhstan and Uzbekistan hinder the efficient and flexible operation of their power systems. These constraints significantly limit the large-scale deployment and integration of renewable energy.

for energy transitions with increasingly clear policy targets. Driven by population growth, accelerated urbanization, and electrification progress, the region's total electricity demand is projected to double by 2050, creating development opportunities in renewable energy, energy storage, and grid infrastructure upgrading.

2. Abundant Renewable Resources and Diverse Market Needs. Boasting abundant wind and solar resources, Central Asia has favorable natural conditions for GW-scale centralized projects. Meanwhile, weak grid connectivity in remote areas has spurred growing demand for distributed energy, microgrids, and energy storage, providing Chinese enterprises with diversified pathways for differentiated project development.

3. China's Global Leadership in Renewable Energy Supply Chains. China has established globally competitive industrial chains in wind power, photovoltaics, energy storage, and UHVDC technology. Chinese enterprises can contribute through equipment exports, EPC services, equity financing, local manufacturing, and joint R&D, helping to build green energy industrial clusters in Central Asia and support local green industrialization and manufacturing capacity.

4. Mature Green Finance Ecosystem in China and RMB Settlement Advantages. China's green finance system is increasingly mature, with innovative tools such as Panda bonds and sustainability-linked loans providing low-cost, long-term financing for clean energy projects in Central Asia. The growing use of local currency settlement also helps mitigate exchange rate risks and strengthen project financial sustainability.

5. High Demand for Clean Energy Talent and Capacity Building. Central Asia faces growing demand for skilled professionals in the clean energy sector. With extensive experience in vocational training and capacity building, China can support the development of localized technical and talent ecosystems through joint training programs and remote learning, thereby enhancing project sustainability.

6. Regional Interconnection Projects Driving Clean Energy Growth. Central Asia is advancing regional interconnection projects, including the Caspian-Black Sea-Europe Green Energy Corridor and the Central Asia-South Asia Electricity Transmission and Trade Project (CASA-1000), which will drive development of clean power and high-voltage transmission projects. Chinese companies can play an active role in equipment supply, system integration, and project financing, contributing to regional power interconnection and cross-border green electricity trade.

• Opportunities:

1. Strong Energy Transition Demand and Policy Clarity. Countries in Central Asia exhibit strong demand

BESS are expected

to play a key role in ensuring the stability and flexibility of energy systems as the use of renewable energy sources continues to expand. At the COP28 climate summit held in Dubai in 2023, around 200 countries agreed to achieve net-zero emissions in the energy sector by 2050, to transition away from fossil fuels, to triple renewable energy capacity, and to double the rate of improvement in energy efficiency by 2030.

Kazakhstan is part of this global trend. The country has set a goal of achieving carbon neutrality by 2060. According to the approved five-year auction schedule, a total capacity of 6.7 GW has been offered for bidding. As a result of the auctions held, 592 MW are planned to be commissioned by the end of 2027. To support these energy transition goals, an Action Plan for the Development of the Electric Power Industry of the Republic of Kazakhstan until 2035 has been adopted. It is worth noting that the implementation of this document also envisions the commissioning of large-scale "gigawatt-class" renewable energy projects. These are wind power projects of 1 GW each, combined with 300 MW energy storage systems, developed in cooperation with companies such as TotalEnergies, Masdar, ACWA Power, China Power, and Hevel (which is implementing a hybrid wind and solar power plant). As a result, the installed capacity of energy storage systems in Kazakhstan could exceed 1 GW over the next decade. If the Action Plan is successfully implemented, the share of renewables in the country's power system is expected to reach 24.4% by 2035.



Timur Shalabayev,
Executive Director of
"Qazaq Green" RES Association

DEVELOPMENT OF BATTERY ENERGY STORAGE SYSTEM (BESS): International Experience

B

ESS plays a critical role in strengthening energy security. Such systems enhance the stability and resilience of power grids and offer backup power solutions for households, businesses, including hospitals and other critical infrastructure. Batteries can also deliver essential services in emergency situations caused by extreme weather or other

disruptions.

The global battery market doubled in 2023, reaching over 90 GWh, with the total volume of deployed batteries increasing by more than 190 GWh. The largest growth in battery sales was observed in utility-scale systems, while behind-the-meter batteries accounted for 35% of the annual increase in 2023. Standalone battery systems currently remain at much smaller volumes. BESS of all sizes are well-suited to provide

short-term flexibility, shifting energy over the course of seconds, minutes, or a few hours, but they can also deliver a broader range of services to support system operation. These include ancillary and backup services, system adequacy support, and congestion management in transmission and distribution networks. Financial incentives, including tax credits and grants, as well as requirements to pair storage with new solar or wind energy projects, are also driving the deployment of these systems. The economic viability of using batteries depends on specific circumstances and individual cases. The answer may vary from region to region, depending on the characteristics of the power system and the regulatory framework. Combining different market mechanisms by providing multiple services simultaneously can improve the economic attractiveness of BESS, but it also increases the complexity of the business case.

UTILITY-SCALE BATTERY ENERGY STORAGE SYSTEMS (BESS)

The deployment of BESS at utility scale is particularly important in power systems with a high share of renewables. These systems can store energy for 1 to 8 hours and are capable of providing peak power: they can be charged during off-peak periods with low electricity demand—for example, during peak solar photovoltaic (PV) generation in the daytime. They are discharged when electricity demand is high, such as in the evening, when solar PV systems no longer produce power. In competitive electricity markets, battery systems can monetize their potential by participating in energy arbitrage, using the advantage of tariff distribution in wholesale electricity markets through charging at low prices and discharging when prices are higher.

Thanks to their instant response capabilities, batteries are also ideal providers of ancillary services in power grids, such as frequency regulation, voltage support, and reserve management. In addition, their black start capability allows them to restore service after system outages.

In many European countries, particularly Germany, Sweden, and the United Kingdom, BESS have already become key providers of frequency and reserve services, supported by reforms that enabled BESS to access the relevant markets for delivering these services. In systems with a growing share of variable renewable energy and declining synchronous generation, driven by the retirement of conventional thermal power plants, there is

a rising need for inertial response and short-circuit power, both of which can be provided by batteries equipped with grid-forming inverters. However, it should be noted that not all grid-forming inverters are capable of providing short-circuit current.

Providing ancillary services has emerged in recent years as an important revenue stream for battery storage systems in several markets worldwide, accounting for over 15% of new project deployments annually, especially for batteries with a two-hour storage duration.

Ensuring sufficient capacity to support system adequacy is also becoming an increasingly common application of battery energy storage. Where regulations allow, participation in capacity markets enables BESS owners to secure long-term revenue streams.

In addition, batteries can help relieve grid congestion by storing excess electricity generated from renewable sources during periods of high output. This reduces the costs associated with curtailment and facilitates better integration of renewables into the power system.

When used for load management, batteries minimize the need for transmission upgrades or investments in the distribution network. This is the primary use case for so-called grid boosters in Germany, the utility-scale batteries deployed to eliminate bottlenecks in the transmission system, thereby reducing the need for additional investment to reinforce specific lines.

The following are various examples of how BESS are used in power systems.

Table 2 – Examples of Utility-Scale BESS Projects

Project Name	Country	Power / Capacity	Market Mechanism	Functional Application
Dalrymple	Australia	30 MW / 8 MWh	Support services	Provides the control of frequency, inertia, and short-circuit current, ensuring reliable power supply for the regional grid with high shares of variable renewable generation and the absence of synchronous generation.
Various sites	United Kingdom	BESS contracts totaling 869 MW	Support services	Provision of inertia and short-circuit current from a grid-forming battery to support the system operator
T1 and T4 Auctions	United Kingdom	BESS capacity growth from 3.9 GW (2024) to 16 GW (2027)	Capacity market	In the UK, where frequency regulation revenues are declining as markets become saturated, multi-year capacity market auctions are becoming an increasingly important revenue stream for BESS

Project Name	Country	Power / Capacity	Market Mechanism	Functional Application
Boulouparis	New Caledonia, France	50 MW for 3 hours	PPA contracts	12-year PPA with the local grid company to cover evening peak demand
Dalian	China	200 MW / 800 MWh	Peak shaving / arbitrage	Designed to reduce peak loads and enhance grid stability by acting as an additional load point on the Dalian Peninsula. The first phase was commissioned in 2022; full deployment is expected to reduce peak demand by 8% compared to 2020 levels.
4 Grid Areas	Germany	950 MW	Grid boosters for transmission system reinforcement	Approved by the regulator BNetzA as part of the Network Development Plan. 450 MW are already under construction by two of the four transmission system operators.
Dunkirk	France	68 MW / 68 MWh	Long-term tender announced by the French transmission system operator (RTE)	Provision of grid services such as frequency regulation – primary reserve
Danish	Texas, USA	720 MW solar power plant and 150 MW / 262 MWh BESS	Arbitrage and ancillary services	The BESS project is designed to perform energy arbitrage, along with providing certain ancillary services for the transmission system operator (TSO). It operates independently of the solar farm, with charging and discharging controlled by the grid operator.
Lokaltstyre – Longyearbyen	Norway	6 MW/9 MWh	Support services	The BESS is sited adjacent to the town's coal-fired power plant and supplies reserve capacity to manage fluctuations, as well as backup power to enable black start capability. Since the coal power plant shut down in 2023, the BESS has taken over voltage and frequency regulation to facilitate the integration of both diesel generators and increasing shares of renewable energy.

Source: Based on the report "Batteries and Secure Energy Transitions" by the International Energy Agency, 2024, and information provided by SAFT.

Figure 1 – Dalian Constant Current Energy Storage Power Station Co., Ltd., featuring a battery energy storage system



The Dalian Constant Current Energy Storage Power Station Co., Ltd., featuring a battery energy storage system designed and manufactured by Dalian Rongke Energy Storage Technology Development Co., Ltd., was implemented with the support of the Dalian Institute of Chemical Physics (DICP) of the Chinese Academy of Sciences. Source: Photo courtesy of DICP.

The regulatory environment and the technical specifications of power networks are key factors shaping the use of BESS. In many jurisdictions with market-based electricity systems, including the European Union, legislation imposes strict limitations on the ownership and operation of energy storage systems by transmission and distribution system operators (with the exception of certain pilot projects, such as grid boosters). As a result, any management services must be contracted out to third parties.

In the UK, local flexibility markets for distribution systems have recently been introduced. These markets are built around open public tenders, where the cost and benefits of flexibility services offered by third parties are compared to the cost of reinforcing the grid. In 2022–2023, over 30% of contracts awarded, amounting to nearly 600 MW of storage, went to such solutions. In France, transmission system operators and certain distribution system operators have recently launched local flexibility tenders open to energy storage projects. In California and New York, distribution system operators are increasingly relying on storage systems that are either co-owned or procured through power purchase agreements (PPAs) with third parties to reduce grid loads, thus avoiding or deferring costly investments in network upgrades.

Microgrids are another utility-scale application of BESS. In Australia and several U.S. states, regulatory authorities have introduced dedicated measures and programs to support the development of microgrids, often built around energy storage systems, in order to enhance the resilience of critical infrastructure such as hospitals,

large industrial facilities, and services for low-income communities.

Microgrids enhance system resilience by allowing operators to disconnect from the main grid through adaptive islanding during major disruptions, maintaining power supply despite the loss of the primary energy source.

Some battery technologies can also be used for multi-day storage, helping to cover extended periods of peak demand or to compensate for episodes of low renewable generation. One such example is a first-of-its-kind 100-hour iron-air long-duration battery project currently under development in California, which is being implemented as part of the state's resource adequacy program. However, under current market structures, most grid services remain focused on short-duration storage. In the U.S., for instance, existing duration requirements for ancillary services (less than one hour) and capacity (four

hours) have shaped the runtime design of most deployed storage systems, which typically operate for four hours or less.

Historically, utility-scale BESS have primarily been used for frequency regulation or shifting electricity demand over time. However, with the growing share of variable renewable energy and the limited size of ancillary services markets, energy shifting has become the dominant application for storage systems. In 2023, this function accounted for around 85% of installed BESS capacity.

In Germany, frequency support was initially the main driver behind utility-scale BESS deployment. But the emergence of new market mechanisms has created additional opportunities for their use, including innovative renewable energy tenders that combine generation with storage, the use of BESS for transmission system optimization (e.g. grid boosters), and optimization of energy consumption at industrial facilities.

If the regulatory framework allows for combining different BESS applications and accessing multiple market mechanisms, this can improve the economic viability of BESS projects and reduce reliance on limited long-term contracts (PPAs). However, achieving this requires more complex energy system management. At the same time, an increase in the number of charge-discharge cycles of BESS also accelerates battery degradation, and not all services are compatible. For instance, if a BESS is optimized for high-frequency, short-duration services, it may not perform effectively when used for longer-duration, non-frequency-based grid support functions.

BEHIND-THE-METER BATTERY ENERGY STORAGE SYSTEMS

Standalone battery energy storage systems are deployed at the distribution level and installed at residential, commercial, and industrial facilities owned by end users. These systems are typically connected directly to on-site or rooftop solar photovoltaic systems, behind the electricity meter, while the building itself remains connected to the grid. They form part of the category of distributed energy resources, which are playing an increasingly important role in the integration of renewable energy sources. These systems can deliver benefits to both consumers and the grid by reducing costs and environmental impact, while enhancing energy security and supporting the electrification of the industrial sector.

Behind-the-meter BESS provide consumers with various opportunities to reduce energy costs. By storing excess solar PV generation during the day, behind-the-meter batteries allow consumers to increase their self-consumption of rooftop solar electricity and reduce reliance on the grid. By charging during periods of low electricity prices, behind-the-meter batteries help consumers lower their electricity bills. BESS can also be used to reduce peak demand, helping consumers save on electricity costs during high-demand periods.

In addition, individual BESS units installed at the household level can be aggregated into so-called virtual power plants (VPPs) and participate in electricity markets. VPPs combine distributed energy resources, including behind-the-meter BESS, distributed renewable generation, and flexible loads, and dispatch them as a single electricity source. To form a virtual power plant, each distributed energy resource must be connected to a centralized control system that optimizes their collective operation and responds to market signals and grid operator instructions. Where market regulations allow, VPPs can sell electricity at wholesale prices, provide ancillary services, and support energy security through capacity services. VPPs also have the ability to respond flexibly to local grid constraints by adjusting the output of individual energy resources within the network. This makes them a potentially valuable tool for relieving congestion in transmission and distribution systems.

In addition to cost-saving benefits, behind-the-meter BESS can enhance the reliability of power supply by providing backup electricity during unplanned outages, an especially critical function for industrial facilities, social infrastructure (such as hospitals), and vulnerable consumers with uninterrupted power needs.

From a system-wide perspective, behind-the-meter BESS can deliver many of the same benefits as utility-scale systems. With the right signals and incentives in place, they can help reduce overall grid demand, alleviate

Behind-the-meter BESS provide consumers with various opportunities to reduce energy costs. By storing excess solar PV generation during the day, behind-the-meter batteries allow consumers to increase their self-consumption of rooftop solar electricity and reduce reliance on the grid.

pressure on the network by limiting peak loads, and provide capacity reserves.

However, compared to utility-scale BESS, behind-the-meter storage systems operate at a local level, which can create opportunities to defer distribution network upgrades or expansion. When aggregated into virtual power plants, behind-the-meter BESS can also provide ancillary services such as frequency regulation, voltage support, and reserve capacity. However, the extent to which behind-the-meter systems can benefit from such deployment largely depends on the regulatory framework, particularly on how end-user tariffs are structured and market access rules for aggregators. It is also influenced by the extent to which smart metering systems have been adopted.



Better
Energy
Security
Sustainability

BESS AS A DRIVER OF ENERGY TRANSITION IN KAZAKHSTAN: Technology, Legislation, Prospects

The event brought together over 300 participants, including representatives of government bodies, leading international companies, research institutions, technology leaders, and investors. The conference was organized by Nazarbayev University, the Qazaq Green Renewable Energy Association, and TotalEnergies Renewables Kazakhstan, with the support of the Ministry of Energy of the Republic of Kazakhstan.

Discussions focused on the potential for integrating Battery Energy Storage Systems (BESS) into Kazakhstan's Unified Power System. Participants explored how these technologies could improve the reliability and flexibility of the power grid, facilitate the integration of renewable energy sources, and enhance the country's overall energy security.

An important part of the discussion addressed international experience with

BESS implementation in Europe, the United States, and Asia, including cutting-edge technologies, business models, standards, and the legal and economic prerequisites for large-scale deployment of storage systems in Kazakhstan.

Key speakers included Sungat Yessimkhanov, Vice Minister of Energy of the Republic of Kazakhstan; Professor Waqar Ahmad, President of Nazarbayev University; Thierry Muller, Vice President of TotalEnergies Renewables; Dyusenbai Turganov, Member of the Mazhilis (Lower House) of the Parliament of Kazakhstan; Nabi Aitzhanov, Chairman of the Management Board of KEGOC JSC; Gulzhan Nalibayeva, General Director of the Financial Settlement Center for Renewable Energy Support; and executives and experts from international

companies such as Huawei, Saft, Sungrow, Envision, and others.

Following the session "International Experience with Large-Scale BESS Projects: Lessons Learned," Thierry Plaisant, General Director of TotalEnergies Renewables in Kazakhstan, stated:

"As a responsible multi-energy leader committed to sustainable development and creating in-country value, TotalEnergies was not just building and operating wind farms. We were also committed to supporting the Republic of Kazakhstan in developing its own advanced expertise in the field of renewable energy. That was why we decided to establish a Competence Center for Energy Storage Systems at the Center for Energy and Advanced Materials Science of the National Laboratory Astana, based



On May 28, 2025, Nazarbayev University hosted the international conference "The Role of Energy Storage Systems (BESS) in the Energy Sector of Kazakhstan."



at Nazarbayev University. We hoped this would help Kazakhstan become one of the global hubs for research into storage and conversion of both conventional and renewable energy."

Special emphasis was placed on the unveiling of Kazakhstan's inaugural White Paper titled "Application of Battery Energy Storage Systems (BESS) within the Unified Power System of the Republic of Kazakhstan." Prepared by the Qazaq Green Renewable Energy Association in partnership with Huawei, the document offered an in-depth look at global BESS implementation, modern technology solutions, international standards, and suggested legal and regulatory measures for Kazakhstan.

Nurlan Kapenov, Chairman of the Board of the Qazaq Green Renewable Energy Association, highlighted:

"At the conference, the Qazaq Green Renewable Energy Association presented the White Paper on 'Application of Battery Energy Storage Systems (BESS) within the Unified Power System of the Republic of Kazakhstan,' prepared by our experts. The White Paper was an analytical report that examined the use of BESS technologies. The report explored international experience with both large-scale industrial deployment of BESS and the use of behind-the-meter BESS at the consumer level. It described current BESS technologies, their market costs, and the international standards applied in BESS project implementation.



"At the conference, the Qazaq Green Renewable Energy Association presented the White Paper on 'Application of Battery Energy Storage Systems (BESS) within the Unified Power System of the Republic of Kazakhstan,' prepared by our experts. The White Paper was an analytical report that examined the use of BESS technologies.



The report also included recommendations from domestic and international experts regarding technical requirements for BESS, as well as suggestions for regulatory and legal frameworks governing these technologies within Kazakhstan's legislation. We hoped this document would serve as a significant initial practical step towards the integration of these technologies into the country's power system."

During the conference, two memoranda of cooperation were signed:

1. Between the Ministry of Energy of the Republic of Kazakhstan, CAEPCO JSC, Huawei, and the Qazaq Green Renewable Energy Association — on the launch of a pilot project for the implementation of a BESS at the 100 MW CAPEC Green Energy wind power plant.

2. Between Huawei and the Qazaq Green Association — on collaboration for a number of future energy storage projects.

Our company intended to implement the first pilot project for a Battery Energy Storage System (BESS) at the 100 MW CAPEC Green Energy wind power plant.

Sun Yaxiu, General Director of Huawei Technologies Kazakhstan, stated:

"At the conference, Huawei signed a Memorandum of Understanding with the Ministry of Energy of the Republic of Kazakhstan, CAEPCO JSC, and the Qazaq Green Renewable Energy Association. Our company intended to implement the first pilot project for a Battery Energy Storage System (BESS) at the 100 MW CAPEC Green Energy wind power plant. We planned to supply and provide full expert and technical support for the 4.4 MW BESS system over a period of one year. Thanks to this project, all interested stakeholders in Kazakhstan would be able to assess the positive impact of our energy storage technology on integrating wind power into the energy system."

A significant part of the program was dedicated to the scientific session on innovations, technologies, and critical materials for energy storage systems.



The session was moderated by Professor Zhumabay Bakenov of Nazarbayev University, Head of the Center for Energy and Advanced Materials Science. His team was recognized as one of the leading research groups in the region specializing in energy materials, advanced energy solutions, and BESS technologies. The session brought together international experts in battery technology and BESS.

Professor Zhumabay Bakenov of Nazarbayev University stated:"

Research in materials science and engineering was enabling the development of more efficient, durable, and sustainable solutions for BESS. In the context of the global energy transition, technological innovation was becoming a key driver of resilience and technological sovereignty for nations. Leading universities and research centers like Nazarbayev University provided the critical scientific foundation needed to advance this strategic field."



Kazakhstan held significant potential in the global battery materials supply chain — particularly in cathode materials, lithium, and other critical minerals — owing to its natural resource base, geopolitical position, and scientific and technological capabilities. At the time, it was essential not only to scale up raw material extraction but also to develop a full value-added cycle, from beneficiation and processing to component

manufacturing and applied research. This approach would have enabled Kazakhstan to secure a strong position in international partnerships and make a substantial contribution to global efforts toward decarbonizing the economy.

The event concluded with the adoption of a resolution defining the main priorities for advancing the deployment of energy storage systems within Kazakhstan's power sector.



The results of the auctions for the selection of renewable energy projects in the first half of 2025.

Date of the auction	Company name	Type of RES	Auction price tg/kWh (without VAT)	Installed capacity, MW
April 15, 2025	Turan Wind Energy LLP	WPP	18.72 tg/kWh	1000
May 26, 2025	Zhassyl Mura LLP	WPP	13.19 tg/kWh	50
May 27, 2025	Zeta Wind LLP	WPP	11.49 tg/kWh	100
May 28, 2025	Green Energy Industrial Company Aktobe LLP	WPP	12.30 tg/kWh	50
June 16, 2025	Vigor Holding LLP	SPP	14.72 tg/kWh	30
June 17, 2025	KSN Solar LLP	SPP	13.99 tg/kWh	20
June 18, 2025	KSN Solar LLP	SPP	13.98 tg/kWh	20
June 19, 2025	Vigor Holding LLP	SPP	13.85 tg/kWh	20
June 23, 2025	Ulken Qaqaq HPP-2 LLP	HPP	40 tg/kWh	2,5
	DOSTYQ-HYDRO LLP		39.67 tg/kWh	0,450
	TAUENERGO LLP		39,72 tg/kWh	3,2
	Jasyl qyat LLP		41,05 tg/kWh	2
	QazQuat-AQSU LLP		40,7 tg/kWh	4,99
	Electrical Energy LLP		41,18 tg/kWh	3,93
	NEK Zharyk Energy LLP		39,69 tg/kWh	8,6
	Smart ReEnergy LLP		40,02 tg/kWh	1
	QazQuat-TURGEN LLP		40,2 tg/kWh	2,6
	GES CORPORATION LLP		39,82 tg/kWh	1
	TK-Most XXI LLP		40,05 tg/kWh	4,9
	Qaratal Hydro LLP		41,17 tg/kWh	4,9
June 24, 2025	KGE Hydro LLP installed capacity of the MW project, auction price (excluding VAT)	HPP	41,23 tg/kWh	27,4
	KazHydroEnergo LLP		41,22 tg/kWh	12,9
	KGE Hydro LLP		41,21 tg/kWh	27,4

Source: Kazakhstan Electric Energy and Capacity Market Operator JSC

Auction

RES AUCTION SCHEDULE IN 2025

The Ministry of Energy of the Republic of Kazakhstan invites all interested parties to participate in auctions for the selection of projects for the construction of renewable generation facilities in 2025.

In accordance with the Order of the Minister of Energy of the Republic of Kazakhstan No. 66-N/K dated February 7, 2025 "On approval of the auction schedule until 2025" the following schedule has been approved:

No	Type of RES	Installed capacity, MW		The UES Zone	Auction date
		Small	Large		
1	WPP		1000*	The Northern Zone	April 15, 2025
2	WPP		50	The Southern Zone	May 26, 2025
3	WPP		100	The Northern Zone	May 27, 2025
4	WPP		50	The Western Zone	May 28, 2025
5	SPP		30	The Western Zone	June 16, 2025
6	SPP		20	The Southern Zone	June 17, 2025
7	SPP		20	The Southern Zone	June 18, 2025
8	SPP		20	The Southern Zone	June 19, 2025
9	HPP	50		All zones	June 23, 2025
10	HPP		200	All zones	June 24, 2025
11	HPP	50		All zones	November 10, 2025
12	HPP		200	All zones	November 11, 2025
13	BioPP	20		All zones	November 12, 2025

Source: Order of the Minister of Energy of the Republic of Kazakhstan No.117- N/K dated March 4, 2025. "On approval of the auction schedule until 2025"

*With an electric power storage system

The total auctioned installed capacity in 2025 is 1,810 MW, broken down by type of power plants:

- Solar Power Plants (SPP) – 90 MW;
- Wind Power Plants (WPP) – 1200 MW;
- Hydroelectric Power Plants (HPP) – 500 MW;
- Biogas Power Plants (BioPP) – 20 MW.



Vision and mission

Bring digital to every person, home and organization for a fully connected, intelligent world

208,000 employees	54% of employees work in R&D	170+ countries and regions	Top 6 in global R&D investment

Huawei is a leading global provider of information and communications technology (ICT) infrastructure and smart devices. The company is committed to bringing digital to every person, home and organization for a fully connected, intelligent world. In the fields of communications networks, IT, smart devices, cloud services, intelligent automotive solutions, digital power, and more, we provide customers with competitive, secure, and reliable products, solutions, and services. Through open collaboration with ecosystem partners, we create lasting value for our customers and society, working to empower people, enrich home life, and inspire innovation across organizations of all shapes and sizes.

Founded in 1987, Huawei is a private company wholly owned by its employees. As of the end of 2024, Huawei had over 208,000 employees, more than 113,000 of whom were R&D employees (54%). We operate in over 170 countries and regions, serving more than 3 billion people around the world.

Huawei global R&D investment has ranked among the top 6 on the EU Industrial R&D Investment Scoreboard for eight consecutive years.

Slide owner: Wang Wanli 00914637, Corporate Brand Mgmt Dept

Latest update: July 2025

Recommended target audience: All

Steady growth of digital power businesses

Stable business growth

Year	Revenue (US\$ bn)
2017	132
2018	156
2019	216
2020	243
2021	298
2022	489
2023	571
2024	687

CAGR: 26.6%

Integrating digital and power electronics technologies to promote green transformation in the industry

- Smart PV:** Global PV inverter shipments in 2024 reached 176 GW, ranked No. 1 globally for 10 consecutive years. Pioneered the shift to string inverters, establishing them as the mainstream technology with a market share of approximately 80%. (Source: Wood Mackenzie)
- Grid Forming ESS:** Cumulative global ESS shipments reached 36.5 GWh. The Smart String Grid Forming ESS underwent a rigorous technology appraisal by five academicians from the Chinese Society for Electrical Engineering, earning recognition as a world-leading solution in GWh-scale applications. (As of the end of 2024)
- Smart Charging Network:** 50,000+ fast and ultra-fast chargers along 50+ highways and in 200+ cities in China. (As of the end of 2024)
- DriveONE:** DriveONE eMobility solution adopted in 50+ vehicle models by 10+ automobile manufacturers, with 1.6+ million powertrains delivered. (As of May 2025)
- Data Center Facility & Critical Power:** Modular UPS ranked No. 1 globally for 9 consecutive years; FusionModule ranked No. 1 in the global modular data center market for 7 consecutive years; FusionDC ranked No. 1 in the prefabricated modular data center market for 10 consecutive years. From&Sullivan, ICTResearch, omdia
- Site Power Facility:** ranked No. 1 globally by serviceable addressable market (SAM) for 12 consecutive years

With the support of customers and partners, Huawei Digital Power has kept growing stably for years and achieved a sales revenue of CNY68.7 billion in 2024, with a compound annual growth rate (CAGR) of about 26.6% from 2017 to 2024.

Huawei Digital Power is committed to integrating digital and power electronics technologies. Its business domains include Smart PV, Grid-Forming ESS, Smart Charging Network, DriveONE, Data Center Facility, and Site Power Facility.

Smart PV: Huawei Digital Power provides FusionSolar All-Scenario Smart PV & ESS Solutions for utility-scale, grid-forming ESS, smart microgrid, commercial & industrial (C&I), and residential markets, including PV inverters and Smart String Grid-Forming ESS. More than a decade ago, Huawei took the lead in introducing string inverters and intelligent technologies into utility-scale PV plants, making smart string inverters the mainstream technical pathway for global PV plant construction, establishing them as the mainstream technology with a market share of approximately 80%. Today, we focus on AI and grid forming technologies in building new power systems based on renewable energy, accelerating wind+PV+ESS to become the main energy sources, and shaping a new era of grid forming. According to Wood Mackenzie's report, the global shipment of Huawei PV inverters reached 176 GW in 2024, accounting for about 30% of the global shipments and ranking No. 1 in the world for 10 consecutive years since 2015. By the end of 2024, the global shipment of Huawei PV inverters had exceeded 621 GW.

Further explanation:

Wood Mackenzie report, July 2025, Global solar PV inverter and module level power electronics market share 2024

Grid Forming ESS: To address the challenges in connecting a high proportion of renewable energy to power grids, Huawei Digital Power offers the Smart String Grid Forming ESS Platform based on a smart string architecture and grid forming algorithms. The solution boosts the grid integration of renewable energy by about 40% to ensure continuous and reliable power supply. By the end of 2024, Huawei had shipped a total of 36.5 GWh of ESSs worldwide. Huawei's Smart String Grid Forming ESS underwent a rigorous technology appraisal by five academicians from the Chinese Society for Electrical Engineering, earning recognition as a world-leading solution in GWh-scale applications.

Smart Charging Network: As a charging network solution provider, Huawei Digital Power has launched an ultra-fast charging solution for passenger vehicles and a megawatt charging solution for heavy goods vehicles (maximum charging power: 1.44 MW). The solutions cover urban public charging stations, inter-city charging stations, dedicated charging stations (heavy goods vehicles, logistics vehicles, and buses), and on-premises charging stations, with the ultimate goal of jointly charging the road ahead and making charging as easy as refueling. By the end of 2024, Huawei FusionCharge has worked with customers and partners to deploy more than 50,000 fully liquid-cooled fast and ultra-fast chargers along over 50 highways (such as Shenhai Expressway, Wushen Expressway, and Jiguan Expressway) and in more than 200 cities (such as Shenzhen, Chongqing, Chengdu, and Shanghai) across China as well as more than 10 regions (such as Türkiye, Thailand, Netherlands, and Germany) outside China. These efforts aim at building unified charging networks for cities and highways.

DriveONE: Huawei DriveONE is positioned as a top-tier e-mobility supplier that is centered on convergence & simplicity, safety & reliability, excellent experience, and cloud-based AI. It provides high-quality and high-performance products and solutions that cover BEV four-wheel drives, DVP distributed drives, and extended-range four-wheel drives to enhance driving experience and help automakers build better vehicles. Huawei DriveONE has cooperated with more than 10 automakers, including Seres, Chery, JAC, and BAIC. Our products have been installed in more than 50 vehicle models, for example, MAEXTRO S800, AITO M9, AITO M7, and LUXEED R7, which are the best-selling cars in their niche market. By May 2025, Huawei DriveONE has shipped more than 1.6 million powertrains, which are widely proven in the market and highly recognized by customers.

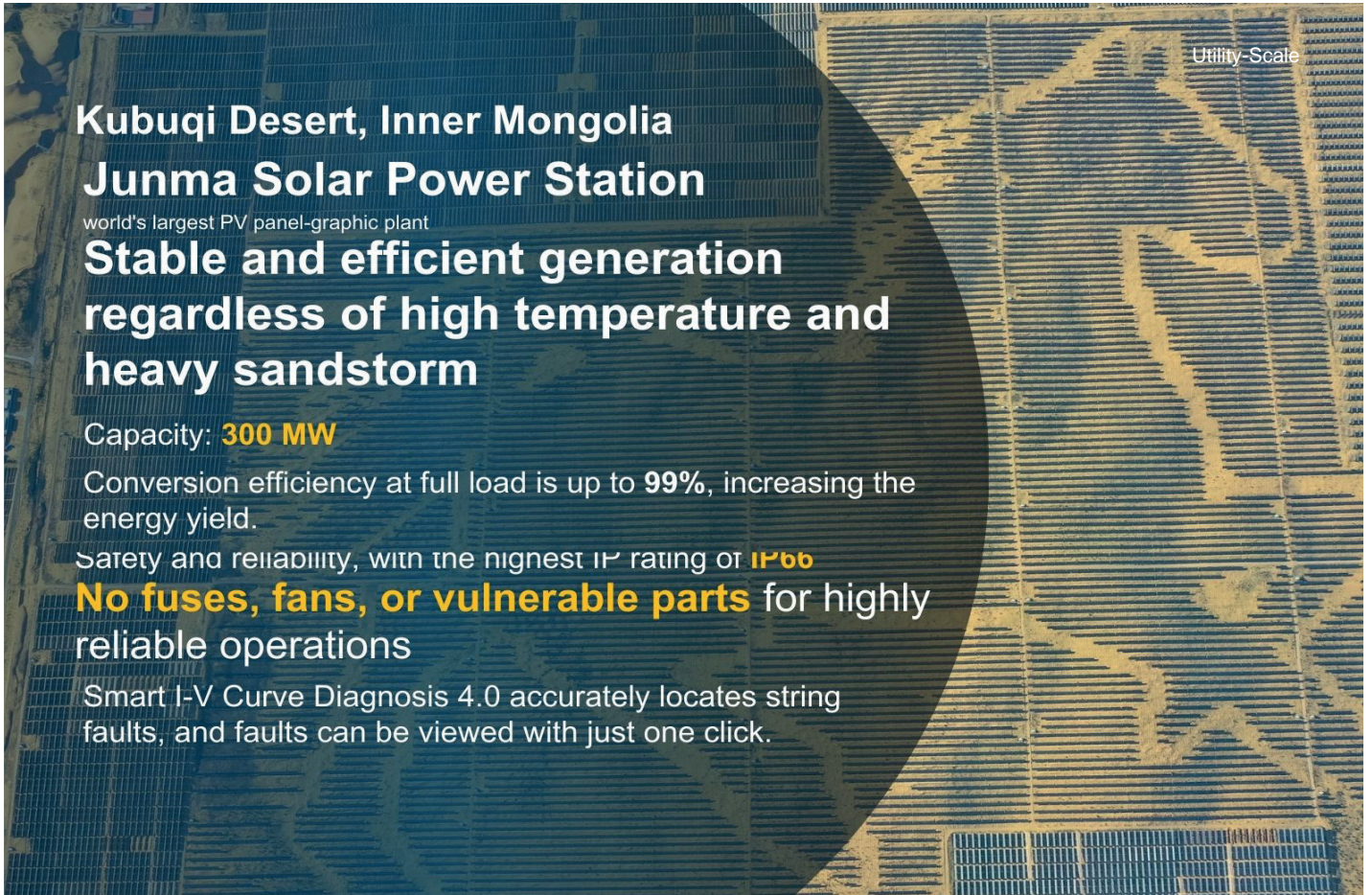
Data Center Facility & Critical Power: A new era of intelligent computing is coming fast. As AI models become more prevalent in various industries, the demand for increased computing power is surging. This has led to the accelerated construction of GW-level intelligent computing clusters worldwide. Based on the innovative concept of Reliable, Agile, and Sustainable (RAS), Huawei Digital Power provides scenario-specific solutions for large, medium and small data centers, and critical power supplies, which include key products such as PowerPOD, UPS, and FusionModule. According to Frost & Sullivan, Huawei modular UPS has ranked No. 1 globally for 9 consecutive years, and Huawei FusionModule has ranked No. 1 globally for 7 consecutive years. According to Omdia, Huawei FusionDC has ranked No. 1 globally for 10 consecutive years.

Site Power Facility: In the global journey to carbon neutrality, Huawei Digital Power helps operators and tower companies build simplified, green, resilient, and reliable energy infrastructure with our "One Cabinet One Site", "One Blade One Site", iSolar PV deployment, and site VPP solutions. Our goal is to accelerate the green and low-carbon energy transition, helping them transform from energy consumers to energy prosumers. According to Frost & Sullivan, Huawei's Site Power Facility market share has ranked No. 1 globally by serviceable addressable market (SAM) for 12 consecutive years.

Slide owner: Zhang Ren 00864548, Digital Power Strategy & Marketing Dept

Latest update: July 2025

Recommended target audience: All



Utility-Scale

Kubuqi Desert, Inner Mongolia

Junma Solar Power Station

world's largest PV panel-graphic plant

Stable and efficient generation regardless of high temperature and heavy sandstorm

Capacity: **300 MW**

Conversion efficiency at full load is up to **99%**, increasing the energy yield.

Safety and reliability, with the highest IP rating of **IP66**

No fuses, fans, or vulnerable parts for highly reliable operations

Smart I-V Curve Diagnosis 4.0 accurately locates string faults, and faults can be viewed with just one click.

In the Kubuqi Desert, Inner Mongolia, China, Huawei helped SPIC build the world's largest PV panel-graphic plant, the Junma Solar Power Station. It is a 300 MW PV power plant with more than 196,000 PV modules, forming "a galloping horse" in this land of re-vitality. The power plant adopts Huawei FusionSolar solution, consisting of 3300 smart string inverters. The inverters use multiple MPPT circuits to solve the problem of string mismatch to the maximum extent for higher energy yield. The inverters are rated IP66, the highest IP rating in China, with no fuse, fan, or vulnerable parts, ensuring high reliability in harsh environments such as high temperatures and sandstorms in a desert. Smart I-V Curve Diagnosis 4.0 revolutionizes the traditional O&M mode. It is similar to a hospital CT scanning, and all plant health problems can be displayed on the large dashboard of the O&M center in one-click mode. PV string faults can be accurately located, diagnosis reports can be automatically generated, and energy yield loss evaluation and rectification suggestions can be provided in a timely manner, helping improve O&M efficiency and energy yields.

Slide owner: Xiao Jinjin 00832789, Smart PV Product Line Marketing Execution Dept

Latest update: July 2025

Recommended target audience: All



The Red Sea destination,
Saudi Arabia, Middle East

World's largest microgrid ESS plant

World's first GW-level grid forming
PV & ESS plant

Smart Microgrid

Capacity: **400 MW PV + 1.3 GWh ESS**

Supporting **100%** renewable energy
Providing over **1 billion** kWh of green electricity
Black start for a **GW-level** plant within **10 minutes**

Rollout in September 2023

In off-grid scenarios, the Smart String Grid Forming ESS Platform provides the continuous fault ride-through capability of 0 to 1.3 times the rated voltage, ensuring continuous power supply and service stability. Generally, power systems need to be shut down periodically every year for maintenance, which inevitably involves system restarts. In the conventional microgrid black start solutions in the industry, diesel generators are used for black start or manual black start is performed for each array. The entire black start process takes two to three days.

The Smart String Grid Forming ESS Platform uses industry-leading grid forming technologies to allow more than 1000 PCSs to run in parallel collaboratively in off-grid mode and support synchronous black start of multiple arrays. The entire microgrid can be black-started in minutes to restore power supply.

With the Smart String Grid Forming ESS Platform, Huawei has achieved 100% PV+ESS grid forming in The Red Sea destination in the Middle East, providing clean electricity for the city that receives nearly one million tourists every year. Since it was put into operation in September 2023, this project has already delivered 1 billion kWh of green electricity to various urban utilities, including airports, hotels, seawater desalination, sewage treatment, and chiller plants. This project has significant social and industry value, as it paves the way for 100% renewable energy supply in the future.

Slide owner: Zhang Zejia 00662076, Smart PV Product Line Marketing Execution Dept

Latest update: July 2025

Recommended target audience: All



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Our Mission:

"We build an energy-efficient future by combining technologies, experience, reliability and long-term value of our solutions"

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WE DESIGN AND IMPLEMENT:



Automated Commercial Electricity Metering Systems (ACEMS)

The ACEMS system allows monitoring actual consumption, forecasting future consumption, eliminating losses and theft, as well as reducing electricity costs. It is an excellent tool for improving transparency and energy efficiency in enterprises and utilities. Additionally, the ACEMS system has the capability to forecast electricity generation for RES facilities. *According to Chapter 2, Paragraph 2, Point 16, Subpoint 6 of the "Rules for Organization and Functioning of the Wholesale Electricity Market," ACEMS is mandatory.



Geographic Information System (GIS)

Based on GIS, digital twins of energy facilities and networks can be effectively developed, ensuring accurate infrastructure representation. Digital twins allow modeling development scenarios, optimizing asset operations and increasing energy system resilience through integration of spatial and temporal data. The Geographic Information System enables calculation of network hydraulic models, formation of precise technical conditions for connections, as well as identification and prevention of losses - from ruptures to unauthorized connections. Additionally, the system provides the ability to assess infrastructure condition and plan repair work with high accuracy. GIS functions are not limited to the above.



Telemetry

Precise collection and transmission of equipment operation data in real time. It ensures control of key parameters and helps quickly identify deviations. In the utilities sector, telemetry is necessary for fair accounting and resource distribution, for industrial enterprises - for energy efficiency control, and for RES - for stable generation monitoring.



SCADA (Supervisory Control and Data Acquisition)

A modern software-hardware complex for monitoring and managing technological processes. It visualizes data, warns about failures and helps operators make real-time decisions. For industrial enterprises, this means complete control and production optimization, for utilities - transparency and work automation, and for RES - effective distributed generation management.



Telemechanics

Combines monitoring and remote control, making process management fast and safe. Industrial enterprises reduce downtime, utilities optimize operations, RES receives efficient generation control.

- **Embamunaigas JSC**
Design and implementation of ACEMS system
- **BaRG LLP Solar Power Plant, Shieli village**
Design and implementation of ACEMS system
- **VIGOR HOLDING LLP 20 MW Solar Power Plant**
Design and implementation of SCADA and ACEMS systems
- **Tesis LLP 40 MW Solar Power Plant** ☀️
ACEMS design
- **Ekibastuz Thermal Networks LLP**
Implementation of digital twin of intra-block and main engineering networks based on geographic information system (GIS) with development of "Defect Elimination Planner" layer, calculation of hydraulic regimes and analysis of network water leaks.
- **Balkhashenergo Municipal State Enterprise**
Design and implementation of ACEMS and telemetry systems.
- **Kazakhoil Aktobe LLP**
Design and implementation of ACEMS system
- **Semizbai-U LLP**
Design and implementation of ACEMS system
- **Shakhtinskteploenergo LLP**
Design and implementation of SCADA and ACEMS systems
- **Astana-Regional Electric Grid Company JSC Development of Design-Estimate Documentation for Working Project with subsequent independent expertise:**
 - "Implementation of ACEMS for legal entities Stage 1 - 2500 metering devices"
 - "Capital repair, installation of ACEMS metering devices at residential facilities in Almaty district"
 - "Private sector ACEMS modernization"
 - "Capital repair of existing ACEMS system"
 - "Private sector ACEMS with overhead input modernization to self-supporting insulated wire - Stage 3"



Portfolio can be viewed by scanning the QR code



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ASSOCIATION AS INFORMATIONAL RESOURCE

The Association is a resource that will allow members of the Association to receive information about changes in legislation immediately.

Association is a resource that creates public opinion, and also contributes to the promotion of renewable energy. It will allow you to form a positive image around an event in the activities of both a member of the Association and the Association itself.



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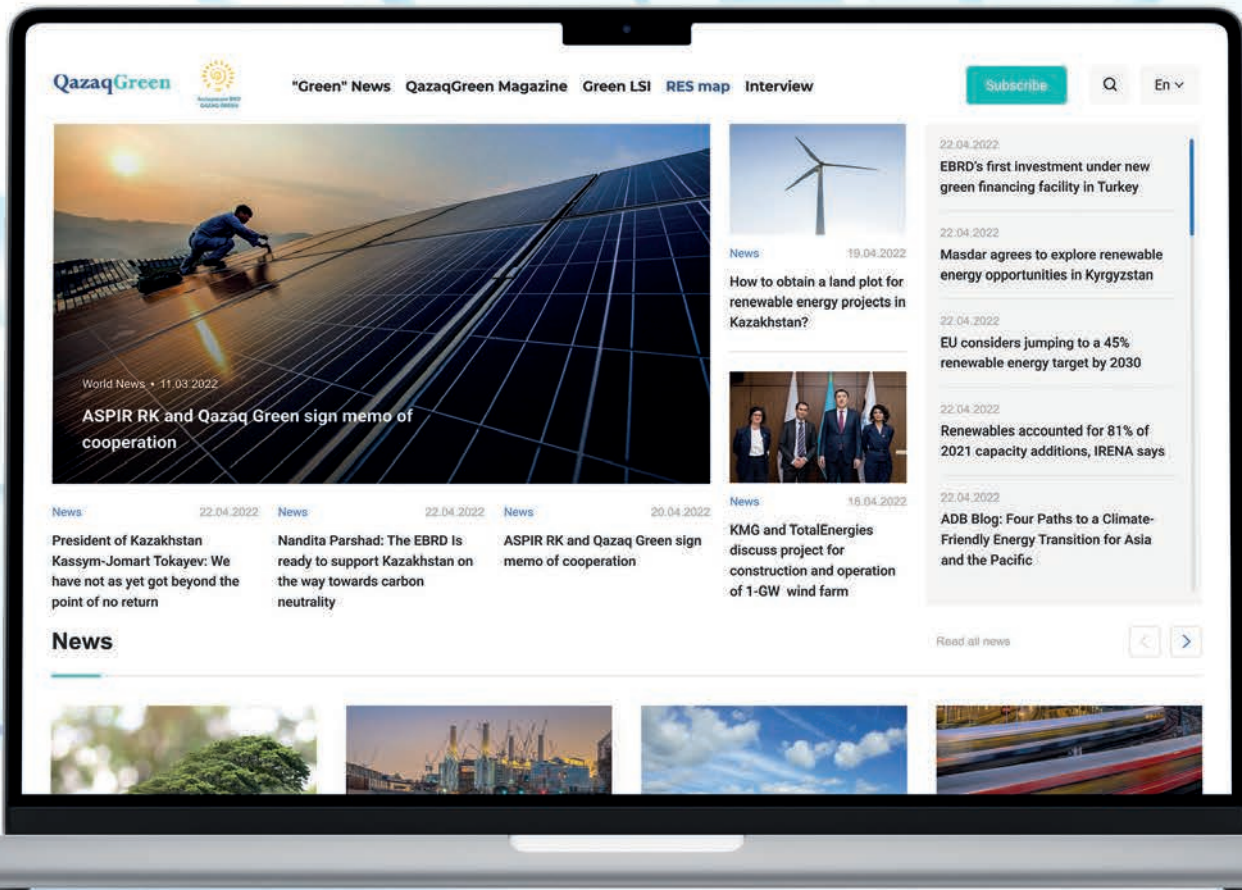
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ZHANAR KUANYSHBEK
Manager



Qazaq Green has launched information portal on "green" economy of Kazakhstan



www.qazaqgreen.com

information portal will present latest news from Central Asia, Kazakhstan and all over the world, as well as articles of QazaqGreen magazine.



The Konrad Adenauer Foundation is a political foundation of the Federal Republic of Germany. With its programmes and projects, the Foundation actively and effectively promotes international cooperation and mutual understanding.

The Representative Office of the Foundation in Kazakhstan began its work in 2007 at the invitation of the Government of the Republic of Kazakhstan. The Foundation works in partnership with government agencies, the Parliament of the Republic of Kazakhstan, civil society organizations, universities, political parties and enterprises.

The main purpose of the Foundation's activities in the Republic of Kazakhstan is to strengthen mutual understanding and partnership between the Federal Republic of Germany and the Republic of Kazakhstan through cooperation in the field of political, educational, social, cultural and economic development, thus contributing to the further development and prosperity of Kazakhstan.

The Konrad Adenauer Foundation has the following priorities in the Republic of Kazakhstan:

- Policy and Party Counselling
- Interparliamentary Dialogue
- Energy and Climate
- Local Self-Governance
- Political Education
- Media
- Sur-Place Scholarships



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