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Better Energy Security Sustainability 2025

The Role of Energy Storage Systems BESS in the energy sector of Kazakhstan

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KONRAD ADENAUER STIFTUNG

FROM THE SPEECH BY KASSYM-JOMART TOKAYEV,
PRESIDENT OF THE REPUBLIC OF KAZAKHSTAN, AT THE INTERNATIONAL CONFERENCE "CENTRAL ASIA FACING GLOBAL CLIMATE THREATS

"

I am convinced that global efforts toward a green transition offer all of us a unique opportunity to build a better, cleaner, safer, and more prosperous world. However, to achieve this, we must secure both public and private financing for climate goals on a meaningful scale. This will reduce the necessity for extensive mitigation measures, facilitate investment in renewable energy, and contribute to building a robust and sustainable economy. Otherwise, the path to carbon neutrality will be jeopardized. To prevent this, we must redouble our efforts, expand, and deepen our partnerships. No country can make such a long and difficult journey alone.

April 4, 2025, Samarkand, Uzbekistan.

Information on the production of electric energy by RES facilities

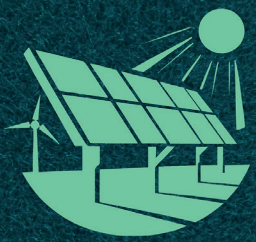
FOR 2024

INSTALLED CAPACITY

including: **3 032,12 MW**

1 520,05 MW — Wind Farms

287,685 MW — small HPPs



Solar Power Plants

1 222,61 MW

Biogas Power Plants

1,77 MW

POWER GENERATION

including: **7 581,33** mln kWh

Wind Farms
4 513,02 mln kWh

Solar Power Plants
1 889,59 mln kWh

small HPP
1 177,13 mln kWh

Biogas Power Plants
1,58 mln kWh

The share of electric power generated by the RES in the total volume of electric energy production **6,43 %**

The increase in electricity generation by RES in 2024 compared to 2023 is **14 %**

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

DEAR READERS! DEAR FRIENDS!

At a recent meeting, the President of the Republic of Kazakhstan, Kassym-Jomart Tokayev, set a task to focus on geological exploration, development, and attracting investment in lithium production. According to various estimates, the country's subsoil holds several hundred thousand tons of lithium.

Currently, lithium-ion batteries hold a dominant position in the battery energy storage systems (BESS) market. In 2023, lithium iron phosphate (LFP) batteries accounted for approximately 80% of the global battery market. Lithium-ion batteries remain a key component of short-duration (<6 hours) energy storage, which is a critical feature for supporting a sustainable energy transition in the Republic of Kazakhstan. This gives us a unique opportunity today not just to implement ready-made solutions, but, leveraging our natural and scientific potential, to position ourselves within the global energy storage supply chain.

Historically, the country's energy system has been based on traditional coal generation and faces a shortage of flexible capacity. Today, this issue is being addressed through the transfer of balancing energy from neighboring countries. In this regard, balancing capacities are already required today to guarantee the country's energy security and the continued growth of green energy.

A potential solution is the adoption of Battery Energy Storage Systems (BESS), which offer the significant benefit of quicker project implementation compared to flexible generation projects (gas and hydroelectric stations). According to estimates by the system operator, the country requires about 2.5 to 3 GW of BESS capacity.

To date, the need for energy storage systems is being actively discussed in our country, yet there is still no hands-on experience with BESS project implementation. Qazaq Green Renewable Energy Association with the support of Huawei Technologies Kazakhstan, has developed a White Paper titled "The Potential of Energy Storage Systems (BESS) in the Unified Power System of Kazakhstan" designed to serve as a guide for advancing this area.

As part of continued discussions, Qazaq Green, in cooperation with TotalEnergies and Nazarbayev University, has initiated the International Conference on "The Role of Energy Storage Systems BESS in the Energy Sector of Kazakhstan" which will take place on May 28, 2025, in Astana. The conference will provide a platform to present the findings of the White Paper, examine leading global practices in deploying BESS projects, and reflect on the fundamental question: Is BESS a strategic imperative or an overrated technology?

We encourage everyone with an interest in the topic to attend and extend our best wishes for a productive and meaningful discussion.

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

THE WELCOME SPEECH OF THIERRY PLAISANT, MANAGING DIRECTOR TOTALENERGIES RENEWABLES SERVICES KAZAKHSTAN

DEAR READERS!

TotalEnergies stands as one of the world's foremost multi-energy companies with over 30 years of successful operations in the Republic of Kazakhstan. The company is one of the key partners (16.81%) in the North Caspian Project consortium, which is responsible for the development of the Kashagan field.

As a global leader in the energy transition, TotalEnergies is committed to making energy cleaner, more reliable, more affordable, and more accessible to as many people as possible. In this context, the company actively supports Kazakhstan's ambition to successfully decarbonize its economy and industry. We are currently actively implementing green energy projects and are already operating two photovoltaic solar power plants with a total capacity of 128 MW in the Kyzylorda and Zhambyl regions.

Building on this momentum, we are now focused on implementing the most advanced, innovative, and large-scale renewable energy project in the region — a 1 GW wind power plant, which will be the largest not only in Kazakhstan, but across the entire Eurasian continent. This project was initiated personally by the President of the Republic of Kazakhstan, Kassym-Jomart Kemelevich Tokayev. In 2023, TotalEnergies signed an agreement with its partners, Samruk-Kazyna JSC and NC KazMunayGas JSC, to develop the wind energy project in the village of Mirny, Zhambyl Region. The Mirny project is part of an intergovernmental agreement between France and Kazakhstan aimed at cooperation in the fight against global warming. Around 200 wind turbines with a total installed capacity of 1 GW will be combined with energy storage systems of 600 MWh, enabling the supply of low-carbon electricity to more than one million people in Kazakhstan.

As a responsible multi-energy leader committed to sustainable development and the creation of in-country value, TotalEnergies goes beyond constructing and operating wind farms — we are also committed to helping the Republic of Kazakhstan develop its own cutting-edge expertise in the field of renewable energy. In line with this vision, we have decided to establish a Competence Center for Energy Storage Systems at the Center for Energy and Advanced Materials of the National Laboratory Astana, based at Nazarbayev University. We hope that this initiative will contribute to Kazakhstan becoming one of the global centers for the research of energy storage and conversion systems for both conventional and renewable energy.

To support this effort, TotalEnergies, in collaboration with the Qazaq Green Renewable Energy Association and Nazarbayev University, has initiated the organization of the International Conference "The Role of Energy Storage Systems in the Energy Sector of Kazakhstan" which will take place on May 28, 2025, in Astana. The conference will feature leading global manufacturers of Battery Energy Storage Systems (BESS), including Saft, Huawei, Sungrow, and Envision, as well as representatives from national companies and relevant government authorities. The sessions will cover international experience in the implementation of BESS projects, Kazakhstan's strategic vision, and the role BESS within the Unified Energy System of Kazakhstan, as well as innovations, technologies, and critical materials used in this field.

On behalf of TotalEnergies, I would like to wish success to all conference participants and take this opportunity to assure you that we will continue to dedicate our efforts to supporting the energy transition process in the Republic of Kazakhstan.

Thierry PLAISANT
TotalEnergies Renewables Kazakhstan
Managing Director

CURRENT ISSUES OF RENEWABLE ENERGY INTEGRATION INTO THE UNIFIED POWER SYSTEM OF KAZAKHSTAN

Bekzhan Mukatov,
Candidate of Technical Sciences,
Energy expert

Despite the progress in the introduction of renewable energy sources (RES) into the Unified Energy System of the Republic of Kazakhstan (UES), several issues related to the integration of RES still remain to be addressed.

The factors hindering the development of RES include a severe shortage of balancing capacities, limited transmission capacity of electricity networks, partly due to their extensive length, as well as a significant need for thermal energy, which exceeds electricity consumption.

Meanwhile, further legal improvements are needed to reduce investment risks and bring more efficient energy sources into the energy balance—particularly by developing microgeneration, which may soon play a major role in ensuring stable and affordable power.

KEY ISSUES AND CHALLENGES

Lack of flexible generation (balancing capacities)

As of today, the main constraint limiting further development of renewable energy and the biggest challenge for the energy sector as a whole is the limited availability of balancing capacities in Kazakhstan.

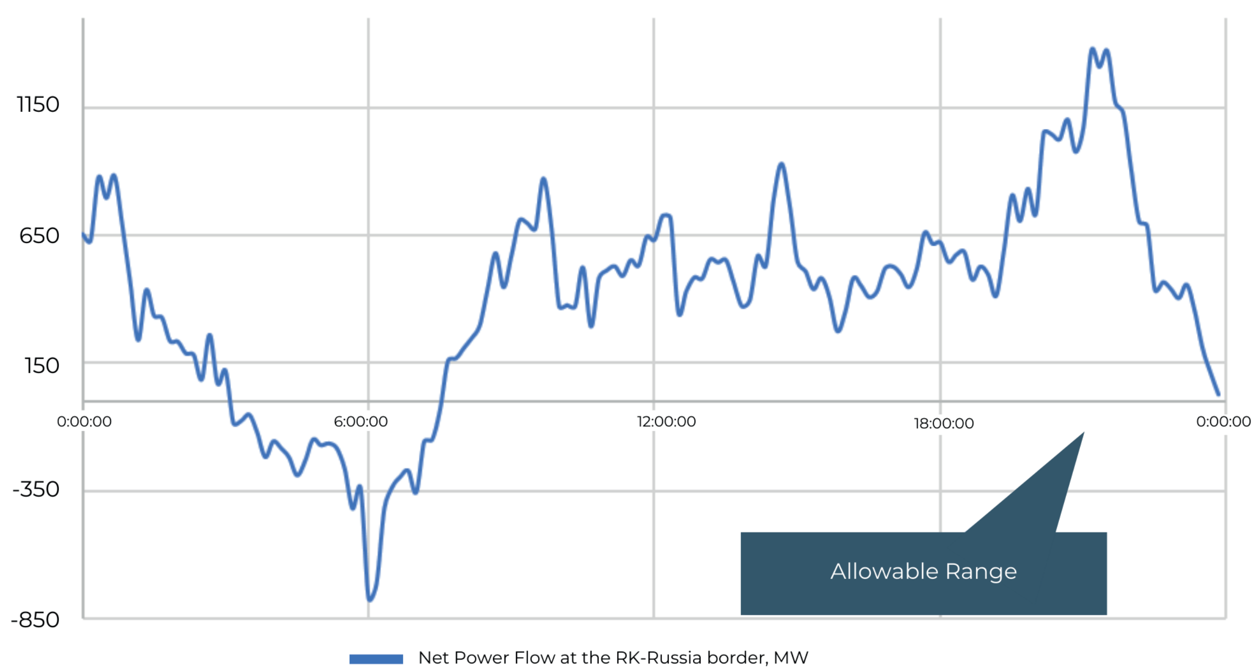
In Kazakhstan, as in many other countries, it is not only impossible to fully abandon traditional energy in favor of renewables but also to achieve the level of renewable energy integration seen in European countries as Denmark - because this is a matter of energy security. In Kazakhstan, renewable energy sources require backup from domestic flexible generation capacities, as external sources cannot provide the necessary reserve capacity required for dynamically developing RES. In countries as Denmark, renewable energy is developing at a rapid pace, with traditional energy sources being actively replaced by renewables. This stems from multiple factors: elevated tariffs, active consumer engagement, and timely deployment of grid stability technologies. A crucial factor, beyond having sufficient domestic flexible reserves, is Denmark's 100% transmission capacity reserve with neighboring countries' power systems. This enables balancing through cross-border electricity exchanges with nations like Norway, Sweden, and others. For this purpose, EU countries maintain extensive intergovernmental energy and economic links, ensuring power exchanges equivalent to Denmark's total energy system capacity. This mechanism of interaction at the supranational level is enshrined in relevant EU directives, which are legally binding, providing a certain guarantee of energy security for countries like Denmark. Under such conditions, Denmark can rely on imports from neighboring European countries to cover its entire required capacity. Spain faces greater difficulties in this regard due to its limited power grid interconnections with France. Compared to Kazakhstan's power system consumption, the available cross-border exchange capacity with neighboring countries is limited. Furthermore, the absence of a unified balancing electricity market in Central Asia's power systems constrains additional opportunities for maintaining grid balance.

The existing generation capabilities in the Republic of Kazakhstan for variable operation modes are insufficient to meet consumer load profiles. Under the current frequency regulation technology within the synchronous area, generation deficits and surpluses relative to consumption lead to imbalances at the border with Russia's Unified Power System.

According to the current capacity balance and generation capabilities, Kazakhstan currently has a formal capacity surplus of several gigawatts. However, accounting for scheduled and emergency power plant maintenance, unavailable capacity due to fuel shortages, equipment degradation, and restrictions imposed by water management practices, this reserve capacity becomes inaccessible during peak demand periods in Kazakhstan's power system. This systematically leads to deviations at the interconnection with Russia's grid reaching 1,000 MW or more.

In Kazakhstan, RES require backup from flexible generation capacity, as opportunities to balance fluctuations through cross-border power exchanges are nearly exhausted. While the permissible power deviation at the Kazakhstan-Russia interconnection is set at ±150 MW, actual deviations reach ±1,000–1,500 MW – exceeding the limit by 10x and often approaching Russia's maximum balancing capabilities.

Figure 1 – Typical Power Imbalances at the Kazakhstan-Russia Border



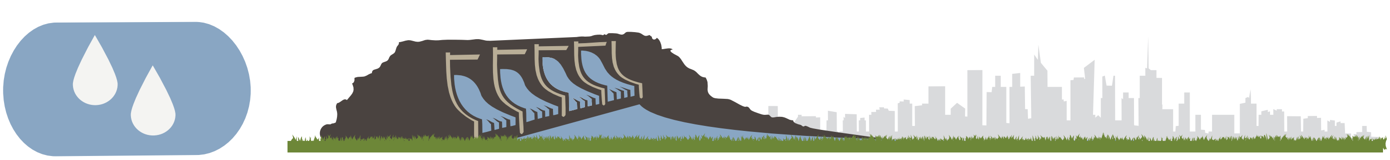
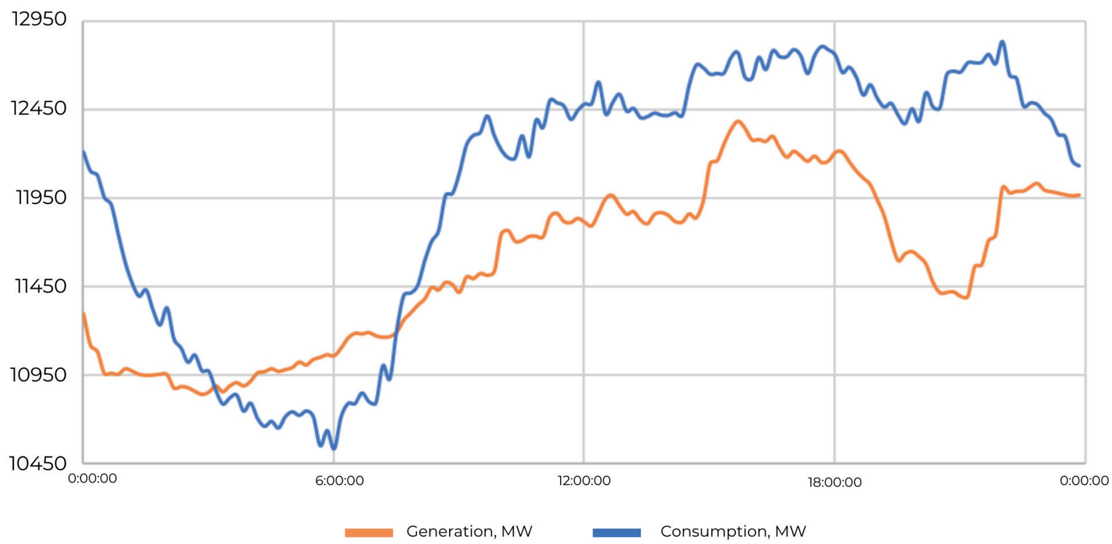


Figure 2 – Typical Power Generation and Consumption in Kazakhstan



Kazakhstan needs to develop flexible generation capacities, as coal-fired power plants, which form the backbone of the country's generation fleet, lack sufficient flexibility. This results in an overall deficiency in the flexibility of Kazakhstan's power system.

Integrating renewable energy into the national power system is becoming increasingly difficult each year, as renewable generation volumes continue to grow while production remains unstable. This challenge can be addressed either by developing additional flexible generation capacities or by implementing energy storage systems – a more costly but faster solution. Both of these solutions require significant investments, extending the payback period of RES projects.

Additionally, the following options could be considered to address the flexible capacity shortage:

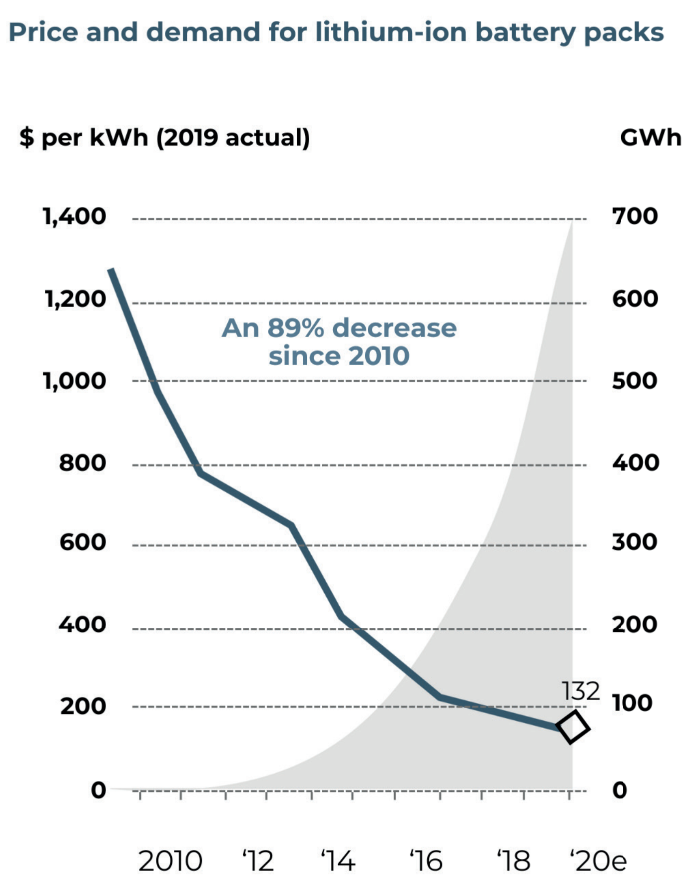
- optimized utilization of existing hydropower plants. Construction of counter-regulators at existing hydropower plants to unlock 'trapped' flexible capacity;
- Encouraging active consumer engagement in power markets via: advanced demand response mechanisms; restoration of differentiated tariffs, stimulating energy conservation measures.

Gas power plant expansion is hindered by congested gas transmission infrastructure, exacerbated by the spatial disconnect between primary gas sources (western regions) and power deficit areas (southern grid). Moreover, gas demand currently outstrips supply capacity.

Previously, there were insufficient market signals for electricity market participants (generators and consumers) to incentivize their engagement in load regulation within the power system. However, the market mechanism established in Kazakhstan's Balancing Electricity Market (BEM) enables the utilization of existing generation and demand-side flexibility potential. This should create conditions for optimized construction of new flexible generation capacity.

Renewable energy accumulation requires energy storage system (ESS) deployment. Several renewable energy projects

Figure 3 – Price Trends of Lithium-Ion Battery Packs



already incorporate energy storage systems. Addressing the issue of balancing capacities through energy storage will become a more attractive solution in the future, given the ongoing cost reduction and extended battery lifespan trends.

The development of hydropower also appears to be an attractive option, as hydroelectric power plants offer high flexibility and low operating costs. Additionally, hydropower has minimal environmental impact and produces no harmful emissions. The key barriers to

Figure 4 – Information on the Utilization of Design Lifespan for Boiler and Turbine Equipment, %

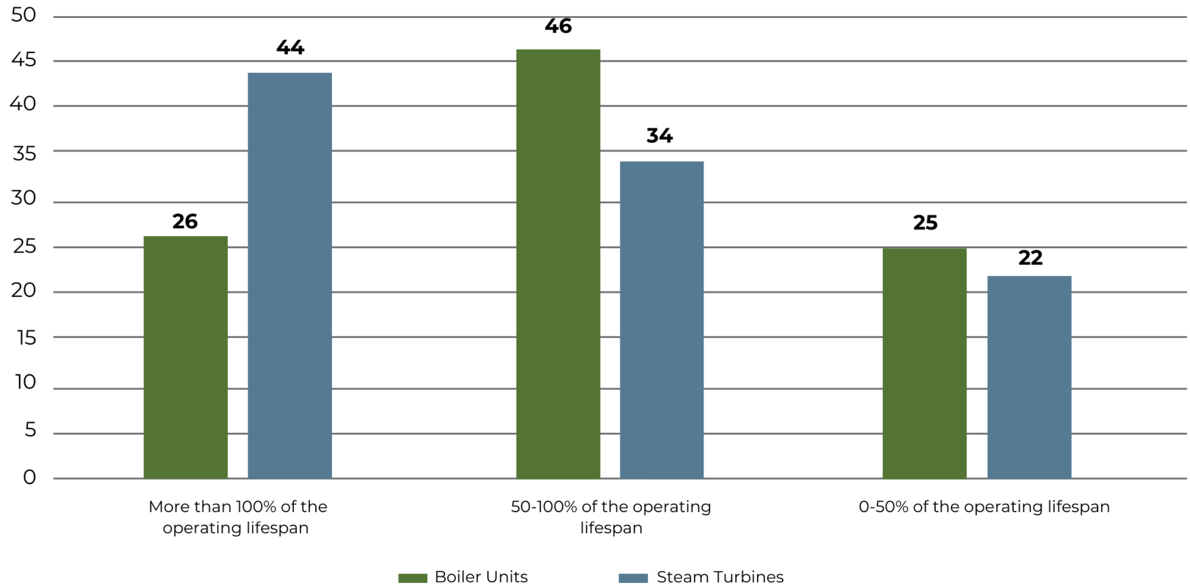


Figure 5 – Information on the Utilization of Design Lifespan for Hydro Units and Gas Turbine Equipment, %

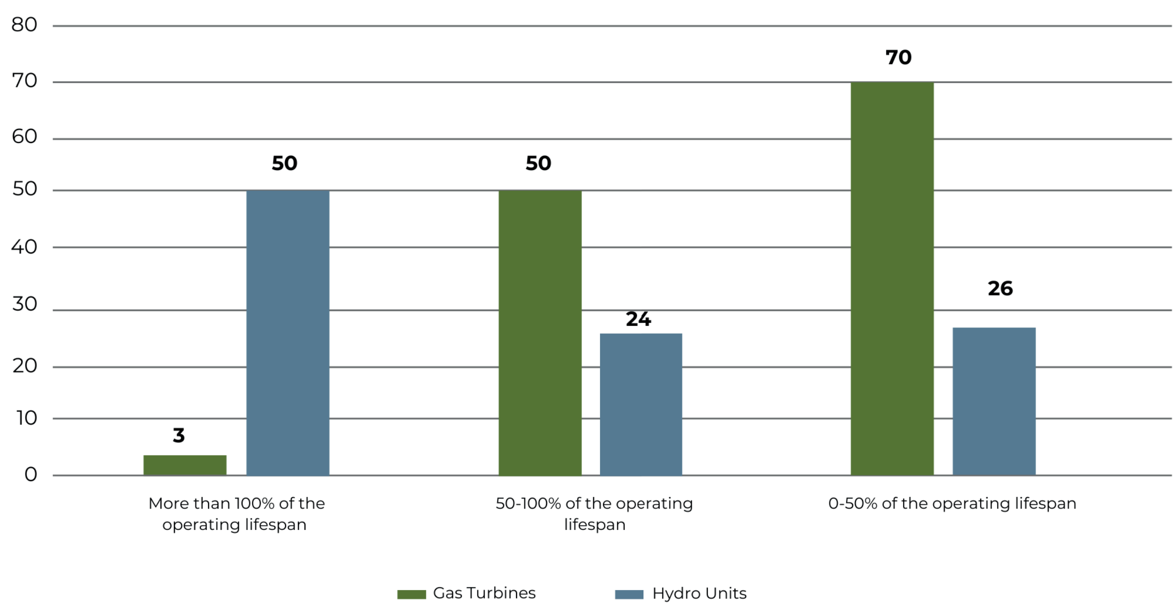


Figure 6 – Age of Generating Equipment at Thermal Power Plants in the Republic of Kazakhstan

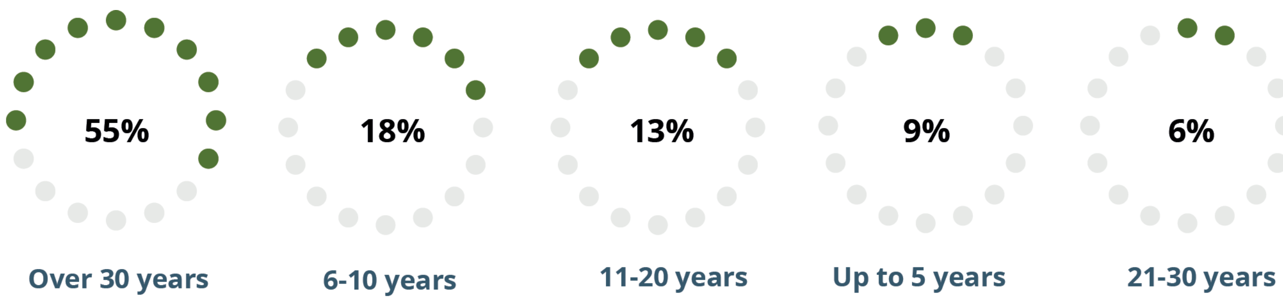
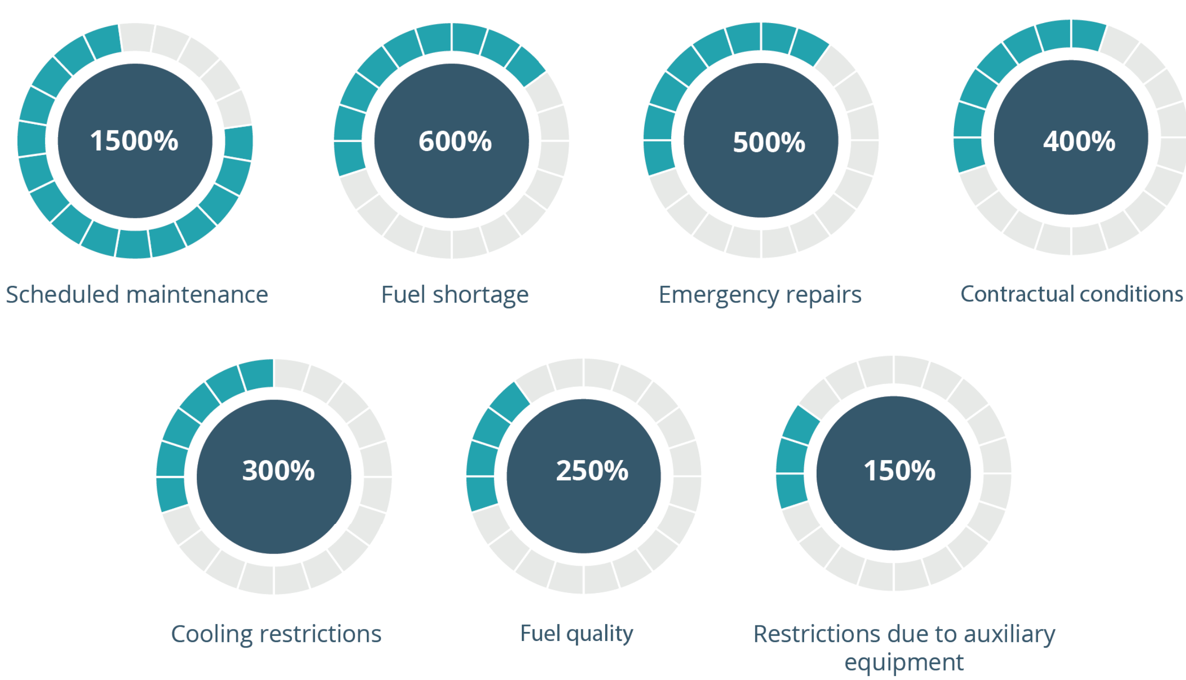


Figure 7 – Age of Generating Equipment at Hydropower Plants in the Republic of Kazakhstan

The number of emergency repairs has been increasing each year:

- In 2022, there were 1,789 technological disruptions at power plants (+23% compared to 2021).
- 3,000 MW – the gap between available and required generation during the peak hour of 2022.

Figure 8 – Average Power Limitations at Power Plants in the Republic of Kazakhstan, MW



hydropower development in Kazakhstan include the high capital investment requirements; the need to preserve fertile land; remote geographical locations of potential HPP sites. A government-led strategic approach to hydropower development planning is essential for maximizing Kazakhstan's hydro potential. This approach will maximize HPP capacity utilization while minimizing capital expenditures.

Demand-side management and price-responsive consumption represent a cost-effective alternative to building new flexible generation capacity. This approach will involve the consumer in the process, help to increase their energy awareness, since in this case they will have the opportunity to participate in the electricity market.

A well-developed ancillary services market with market-based pricing enables the procurement of sufficient balancing capacity regardless of the type of flexibility source, which, in turn, will facilitate the establishment of fair pricing in the energy market, assuming an electricity surplus. In the presence of an operational balancing market with sufficient flexible reserves, conventional power plants and RES will be able to compete under more equal conditions.

Degraded State of Conventional Generation Assets

According to the Committee for Atomic and Energy Supervision and Control of the Ministry of Energy of the Republic of Kazakhstan, the Unified Power System of Kazakhstan is experiencing a high level of wear and tear in its generating equipment. A significant portion of the operating equipment has exceeded its design lifespan. The figures below provide information on the operational hours of boiler units, steam turbine equipment, hydro units, and gas turbine equipment.

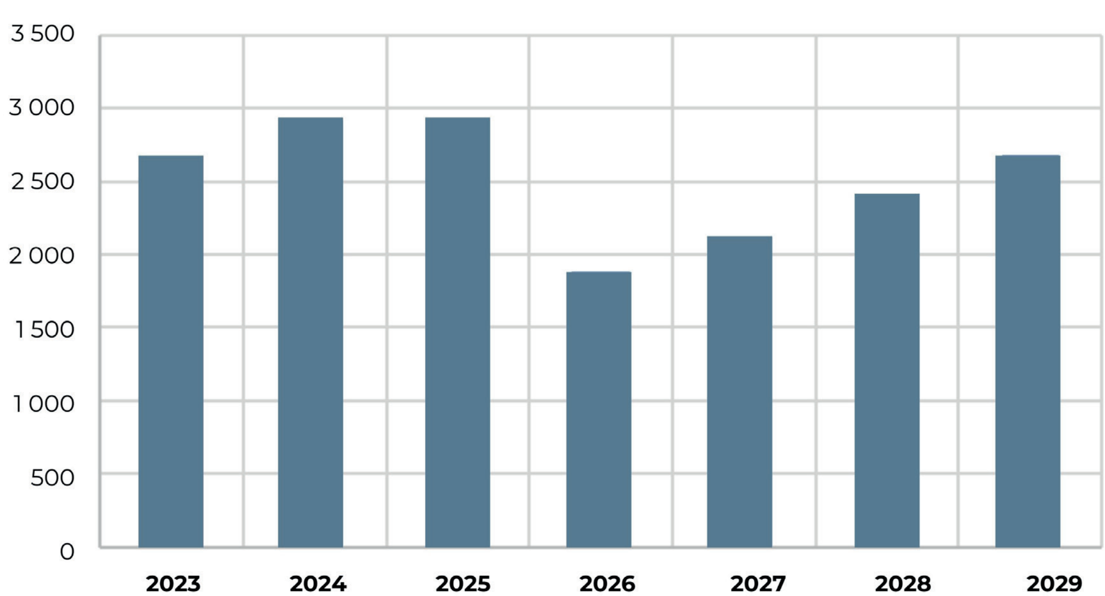
The Need for Power Grid Development

For renewable energy to develop effectively in Kazakhstan, a well-developed infrastructure is essential—not only flexible power plants but also an extensive electricity network with high transmission capacity.

One of the key features of Kazakhstan's power system is the uneven distribution of generation and consumption hubs. The majority of power generation is concentrated in the Northern zone, while the densely populated southern regions of the Republic are demonstrating the most dynamic growth in electricity consumption, averaging around 5% per year. Currently, the Southern zone experiences an energy deficit of approximately 2,000 MW, and according to the forecast balance, this deficit is expected to persist in the coming years.

Another feature of Kazakhstan's power system is that the electrical grid does not cover large (sparsely populated) areas of the country, which limits the ability to connect renewable energy facilities to the National Electric Grid. The diagram below presents maps of solar and wind resources across Kazakhstan. When comparing these resource maps with the diagram of Kazakhstan's electrical grids, it is evident that a significant portion of potential renewable

Figure 9 – Projected Power Deficit in the Southern Zone of Kazakhstan's Unified Power System



energy installation sites has limited access to the main grid. Developing renewable energy projects in these locations would require additional investments in grid infrastructure and connection.

Issues with the Stability of Parallel Operation

The energy deficit in the Southern zone is primarily covered by electricity supplies from the energy-surplus Northern zone through the extensive 500-220 kV North-East-South transit. As a result, the main stability issues in Kazakhstan's unified energy system are observed in the transit connecting the Northern and Southern zones. The intermittent nature of renewable energy generation requires constant balancing. Given that balancing capacities are mainly located in the Northern zone, the imbalances in the Southern zone are compounded by the power flow through the North-East-South transit. It should be noted that the transmission capacity of

Figure 1 – Data on Solar and Wind Resources and the Location of New PV Capacities in 2020.

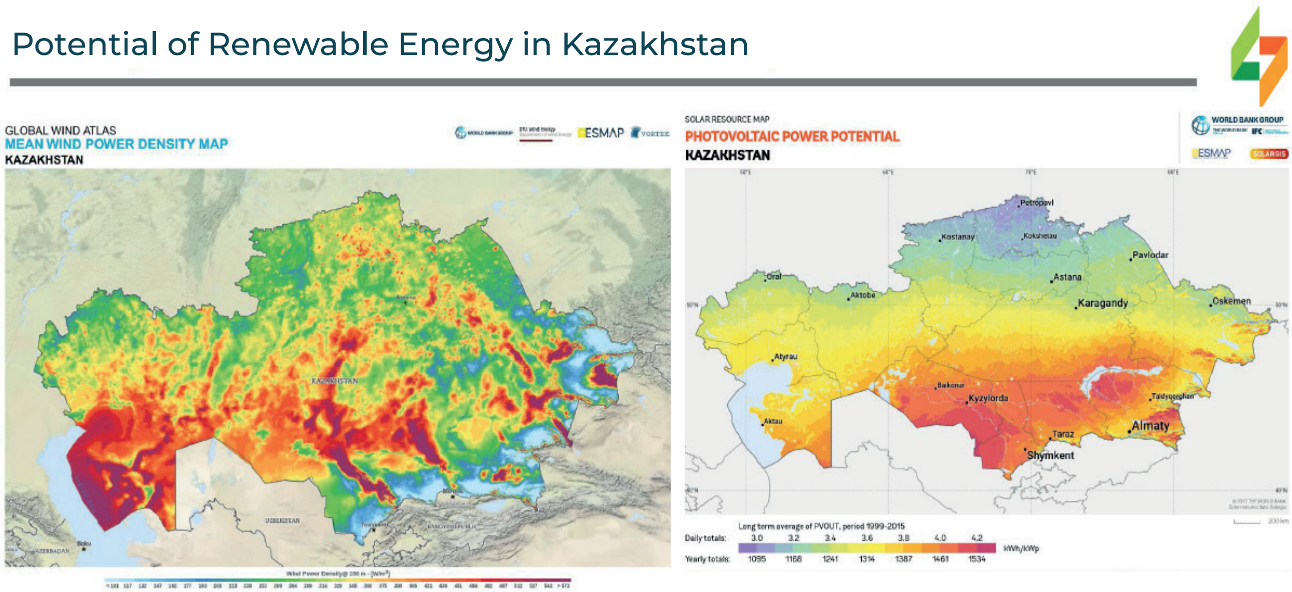


Figure 2 – Schematic Map of the Power Grid of the Republic of Kazakhstan

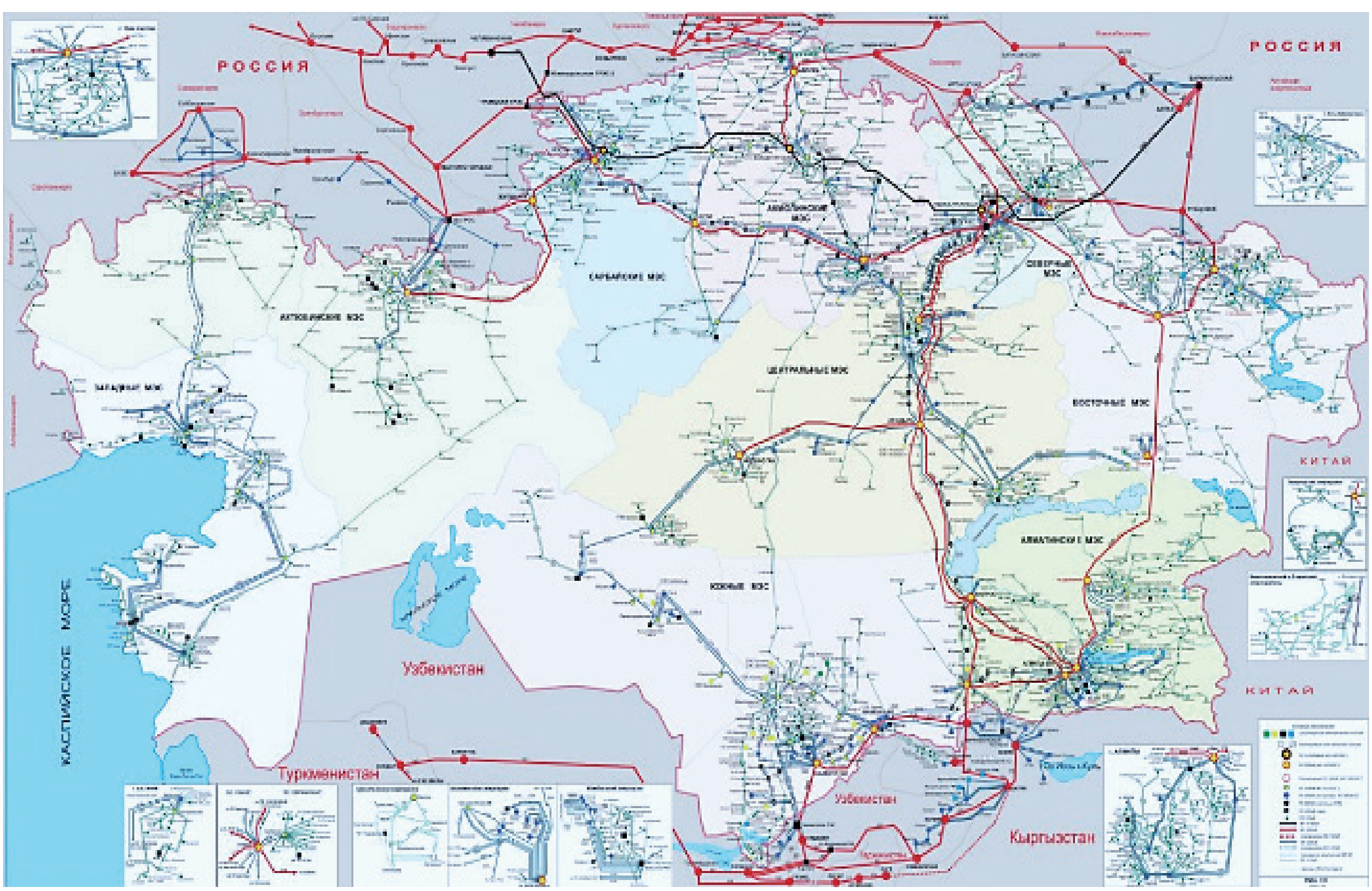
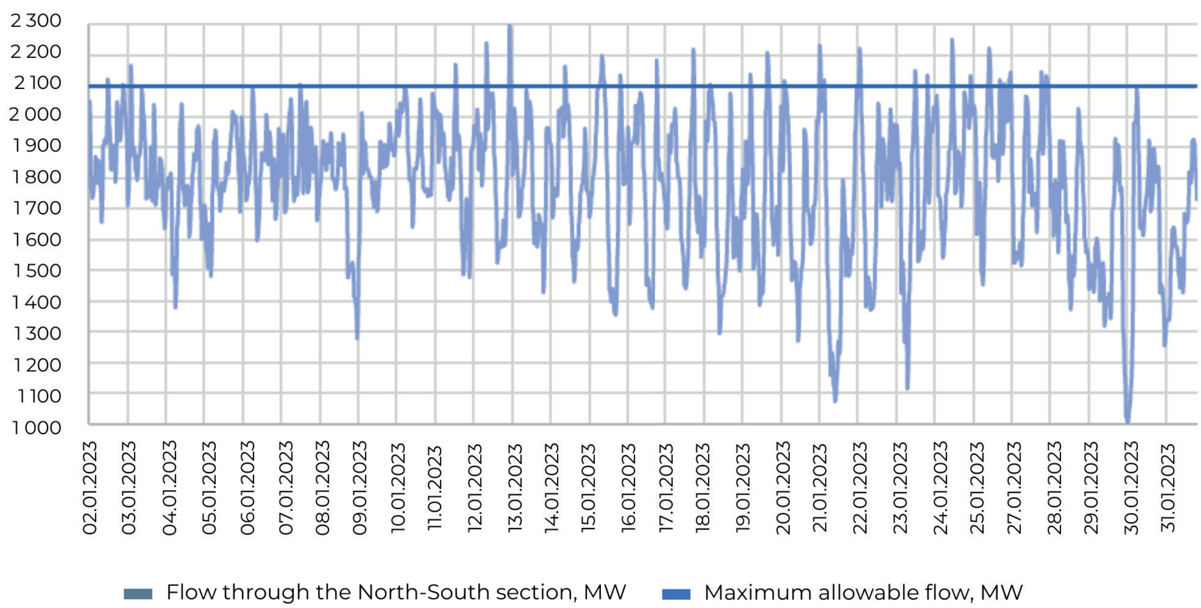


Figure 10 – Typical Load of the North-South Transit during the Winter Month.



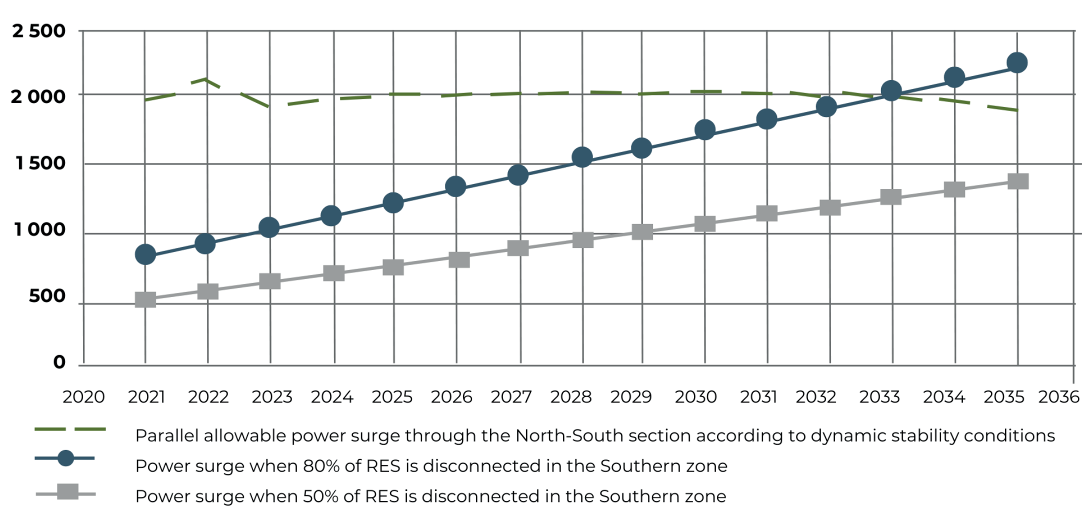
this corridor is almost fully utilized.

The impact of the integration of renewable energy sources on the stability of the North-South transit was examined by specialists in 2018. The study analyzed a scenario of the loss of part of the RES generation in the Southern zone, leading to a power draw on the North-South transit. At the 2021 consumption level, the transmission capacity of the North-South transit allowed for reserving potential generation losses in the Southern zone through power flow from the Northern zone.

However, with an annual consumption growth rate of 5% in the Southern zone and the planned increase in the share of RES, this growth will not be sufficient to cover the deficit. At the same time, the increasing share of renewable energy sources leads to higher potential power surges at the grid section.

Considering the significant share of renewable energy sources, especially in the south of Kazakhstan, stability issues become even more relevant due to the reduction in system inertia. An update of the regulatory legal acts of Kazakhstan governing the reliability requirements of the UES is already required. These should address measures to prevent unacceptable conditions in the power system, where the reliable operation of the UES cannot be ensured under normative emergency situations.

Figure 11 – Power imbalances at different percentages of RES disconnection in the Southern zone



APPLICATION OF BATTERY ENERGY STORAGE SYSTEMS (BESS) IN THE UNIFIED ENERGY SYSTEM OF THE REPUBLIC OF KAZAKHSTAN

Inna Kim,
Deputy Director of Energy System Researches LLP

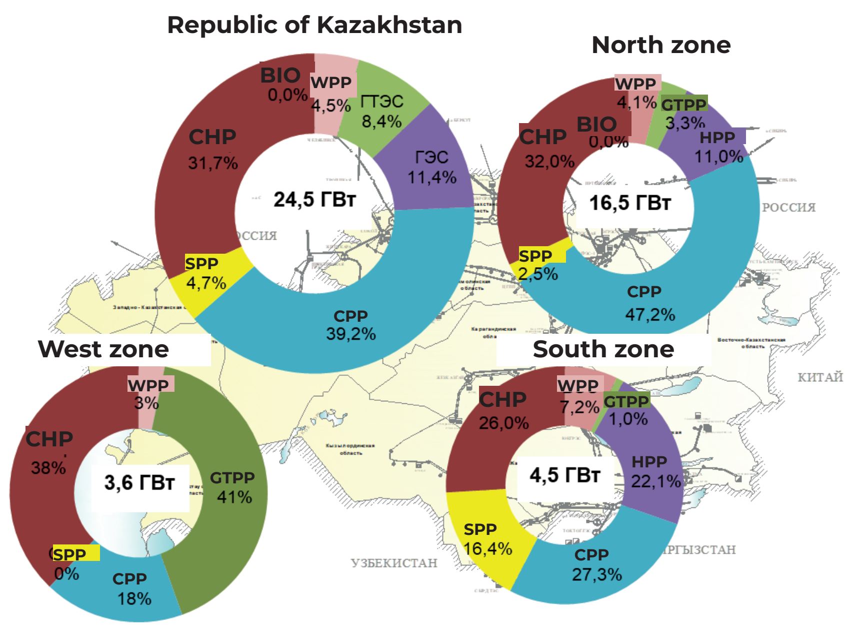
1. The relevance of Battery Energy Storage Systems (BESS) for Kazakhstan

International experience demonstrates a wide range of applications for BESS, with the key ones being peak load shaving, uninterrupted power supply, frequency regulation, voltage fluctuation smoothing, deferral of grid upgrades, maximization of existing grid capacity, and more. At the same time, to assess the feasibility, implementation potential in various scenarios, and effective use of BESS in Kazakhstan, it is essential to consider the following specific characteristics of the energy system.

Structure of Traditional Generation by Zone and Type

In the structure of installed capacity at power plants in Kazakhstan by electricity generation technology, thermal power plants accounted for 19.46 GW in 2022, making up 79.4% of the total installed capacity. This includes: condensation power plants – 9.6 GW (39.2%), combined heat and power plants (CHP) – 7.8 GW (31.7%), gas turbine power plants – 2.06 GW (8.4%).

Figure 1 – Structure of Installed Capacity of Power Plants in Kazakhstan by Electricity Generation Technology in 2022.



Source: KEGOC JSC

The generation structure varies across different zones. Gas turbine power plants (GTPPs) are primarily located in the Western zone, while large hydropower plants (HPPs) are concentrated in the Northern and Southern zones.

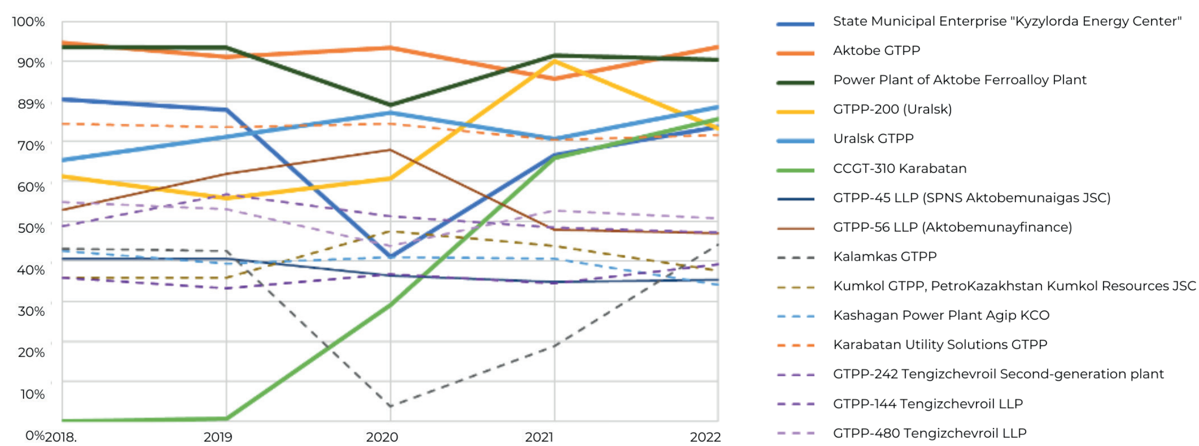
Due to their technological characteristics, GTPPs and HPPs have the best capability to rapidly adjust generation, allowing for quick ramp-up and ramp-down. However, it is important to note that in Kazakhstan, only four out of six large HPPs participate in grid regulation.

Table 1 – Operational Flexibility of Kazakhstan's Hydropower Plants

№	Name	Region, placement area	Installed capacity, MW	Regulating capacity	Note
1	Bukhtarma HPP	East Kazakhstan Region, Northern Zone	675	Available	
2	AES Ust-Kamenogorsk HPP LLP	East Kazakhstan Region, Northern Zone	380	Absent	Counter-Regulating Reservoir of Bukhtarma
3	AES Shulbinsk HPP LLP	Abai region, Northern zone	702	Partially available	The maximum load in winter does not exceed 200 MW, the regulation capacity is up to ≈± 40 MW
4	Kapshagai HPP	Almaty region, Southern zone	364	Partially available	Regulation is carried out within a range of up to ≈±100 MW, primarily during the winter period.
5	Moynak HPP	Almaty region, Southern zone	300	Available	
6	Shardara HPP	Turkestan region, Southern zone	126	Absent	

An analysis of the reported capacity factor values of gas turbine power plants (GTPPs) shows that, with the exception of power plants in the oil and gas sector, which cover their own load with a nearly proportional reserve, the main GTPPs operated primarily in a baseload mode with a capacity factor of 74–90%, not fully utilizing their regulation range.

Figure 2 – Capacity Factor of Gas Turbine Power Plants (GTPPs) for the Period 2018–2022



Note: Dashed lines represent power plants covering their own load.

Plans for the Development of Renewable Energy Generation by Zone and Type

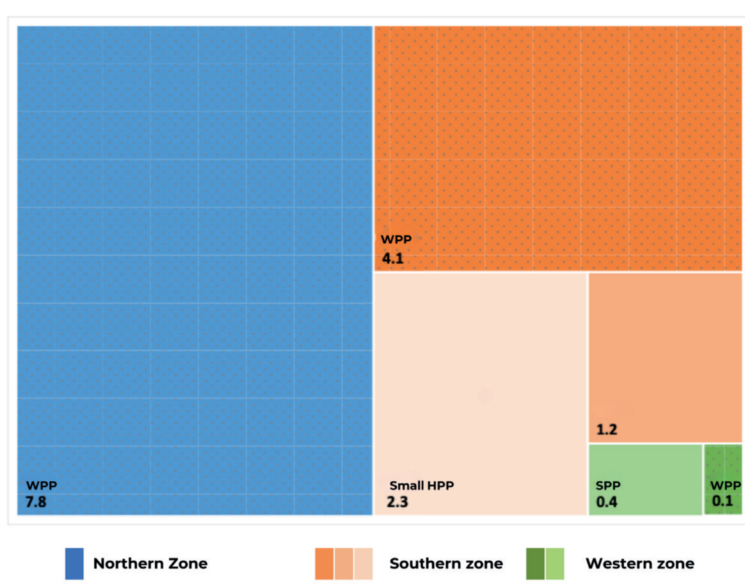
The renewable energy development targets are outlined in the following documents:

- Forecast Energy Balance of the Republic of Kazakhstan until 2035 (Order of the Ministry of Energy of the Republic of Kazakhstan No. 44 dated January 30, 2023);
- Auction Schedule for 2024–2027 (Order of the Ministry of Energy No. 187 dated May 23, 2023);
- Action Plan for the Development of the Electric Power Industry until 2035 (Order of the Ministry of Energy No. 71 dated February 20, 2024).

According to the planned indicators for 2035, a total of 15.8 GW of renewable energy capacity is expected to be commissioned, including 12 GW of wind power (WPPs), 2.3 GW of small hydropower (SHPPs), and 1.6 GW of solar power (SPPs).

The distribution of planned renewable energy capacity by zone and type is shown in the figure below.

Figure 3 – Breakdown of Planned Renewable Energy Capacity by Zone and Type for 2035, GW

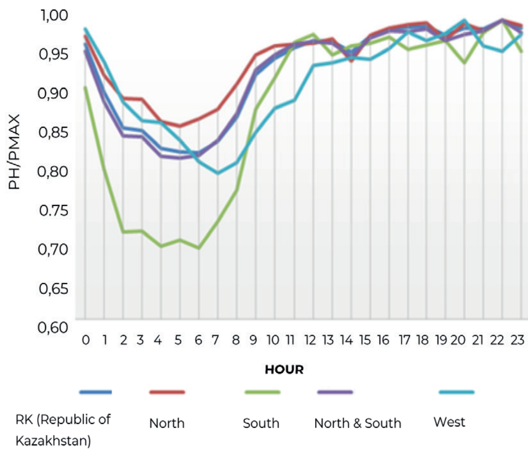


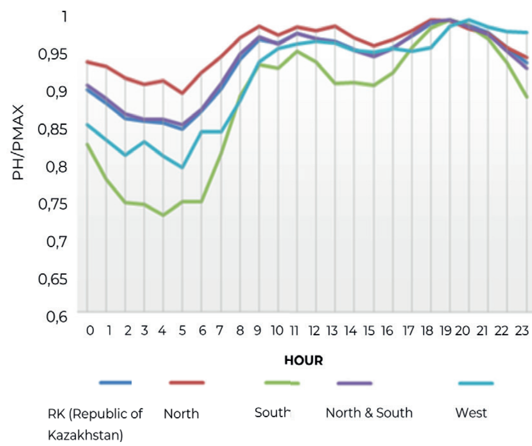
An analysis of the projected renewable energy capacity additions for 2035 indicates that the majority of the increase in installed renewable energy capacity is expected in the Northern (49%) and Southern (48%) zones of Kazakhstan's power system. In the Northern zone, development will rely exclusively on wind power (WPPs), while in the Southern zone, capacity additions will include wind (WPPs), solar (SPPs), and small hydropower plants (small HPPs).

Load Profile

The Southern zone has the least uniform and densest load schedule due to the significant share of residential and commercial consumption. All analyzed daily load curves exhibit peak demand periods during the daytime (10÷12 hours) and nighttime (19÷23 hours).

Figure 4 – Typical Daily Load Profiles for Summer and Winter Days Based on Control Measurements





Power Grid Infrastructure

The total length of transmission lines and substations within Kazakhstan's National Power Grid (Overhead power lines and substations), owned by KEGOC JSC as of December 31, 2022, is outlined below.

1,150 kV (including 500 kV) - 1,421 km

500 kV - 8,282 km

330 kV (including 220 kV)- 1,863 km

220 kV -14,890 км

Limited Transmission Capacity of the North-South Transit.

The transmission capacity of the North-South transit in its current state, at the limiting section (Agadyr – South Kuzbass Power Station), is estimated at approximately 2100 MW in the north-to-south direction and 2400 MW in the south-to-north direction.

Parallel Operation with the Power Systems of Russia and Central Asia (Kyrgyzstan and Uzbekistan).

An analysis of the hourly balances across Kazakhstan's power system showed that for 97% of the time, imbalances remained within the range of ±1000 MW and were compensated through power exchange flows with neighboring power systems. However, the existing contractual obligations for cross-border electricity flows stipulate that exchange flows must be maintained within ±150 MW with the Russian power system and ±50 MW with the Central Asian power system.

Lack of an Up-to-Date Reliability Standard for Power System Operation.

The regulatory volume of primary and secondary capacity reserves is defined by Kazakhstan's Power Grid Rules: primary reserve – 2.5% of the available generation capacity, secondary reserve – 8% of the peak load, but no less than the installed capacity of the largest generating unit.

However, as the share of renewable energy increases, this standard requires revision, as renewables introduce significant uncertainty into the overall generation balance. This, in turn, increases the uncertainty of the "net" load profile, which must be covered by conventional power plants[1].

Mechanisms for Investment Returns

Kazakhstan currently operates a capacity market, a wholesale electricity market, and a balancing market, along with additional payments for power plants participating in the centralized Automatic Frequency and Power Regulation System (AFPRS).

Subject to a positive techno-economic assessment, BESS deployment in Kazakhstan is possible both as an independent business (arbitrage) and in combination with other technologies (renewable energy generation, system services, etc.).

[1] It is necessary to conduct a study to assess the need for reactive power, focusing on voltage stability at the connection point. The approach used in the Grid Rules requires revision.

Figure 5 – Relevance of Battery Energy Storage Systems for Kazakhstan

Arbitrage

Service	Power	Capacity	Frequency of use
Wholesale market arbitrage	Determined by the market	≥2 h	≥1 time per day
Balancing market arbitrage	Determined by the market	≤2 h	≤1 time per day

Wind and Solar Energy Generation

Service	Power	Capacity	Frequency of use
Reducing forecast errors	≤30% of Inst. Cap	≤2 h	≤1 time per day
Reducing generation curtailment	≤30% of Inst. Cap	≥2 h	Varies by season

Grid Operator

Service	Power	Capacity	Frequency of use
Transmission line unloading and modernization deferral	≤100 MW	≤4 h	Varies by season
Anti-emergency control	<100 MW	≤1 h	>1 time per year

System Services

Service	Power	Capacity	Frequency of use
Power flow regulation (Automatic Power Flow Control)	>100 MW	≤2 h	≥1 time per day
Emergency reserve	>100 MW	≤4 h	≥1 time per year
System loss optimization	> 100 MW	≤4 h	≥1 time per day
Voltage control	>100 MW	≤4	≥1 time per day
Inertia control	>100 MW	≤1 h	<1 time per year
Frequency control	>100 MW	≤1 h	<1 time per year
Load supply assurance	>100 MW	≤1 h	<1 time per year
Black start	<100 MW	≤1 h	<1 time per year

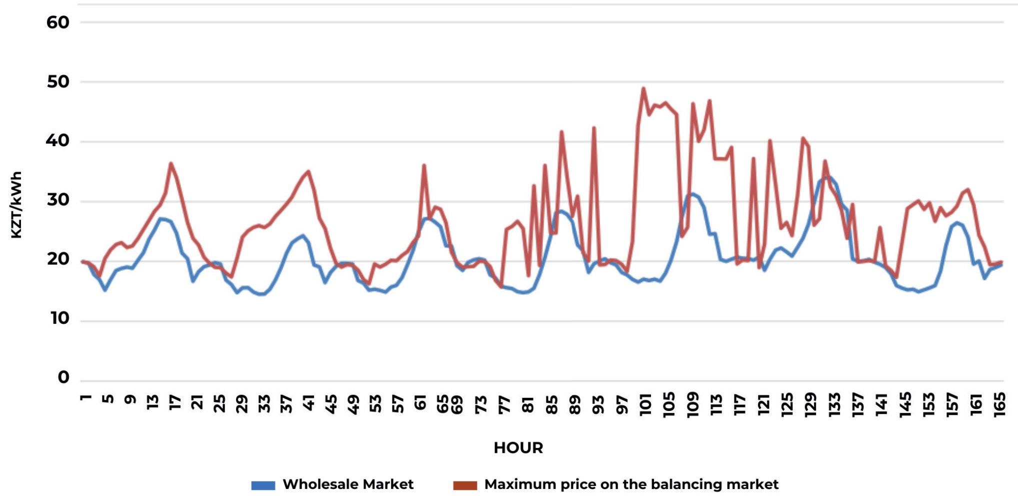
Electricity Capacity Market Balancing Market Capacity Market Electricity Market

Arbitrage – the purchase of electricity during off-peak hours on the wholesale or balancing market and its sale during peak hours.

According to KOREM JSC, in September 2024, the minimum and maximum imbalance prices on the balancing market ranged from 0.01 to 63.21 KZT/kWh. Meanwhile, on the day-ahead wholesale market, data from SFC LLP indicates that electricity prices varied between 12.62 and 35.6 KZT/kWh depending on the hour. At the same time, the wholesale market exhibits relatively clear price trends with lower uncertainty, whereas the balancing market is characterized by high volatility and significant uncertainty.

[2] Kazakhstan's power system has strong interconnections with Russia's power grid, where Russian power plants regulate the frequency of Kazakhstan's grid and those of other Central Asian countries. Moreover, the "dead band" for power plants in Kazakhstan is 200 mHz, whereas in Russia, it is 150 mHz. This means that Russian power plants respond more quickly to frequency deviations.
Given this, a significant frequency deviation in Kazakhstan's power system is unlikely, and the estimated frequency of occurrence is less than once per year (as shown in the last column of the figure on the right). This point does not apply to local frequency drops caused by limited transmission capacity or emergency shutdowns.

Figure 6 – Hourly Price Dynamics on the Day-Ahead Wholesale Market and Maximum Prices on the Balancing Market (Weekly Data, September 2024)



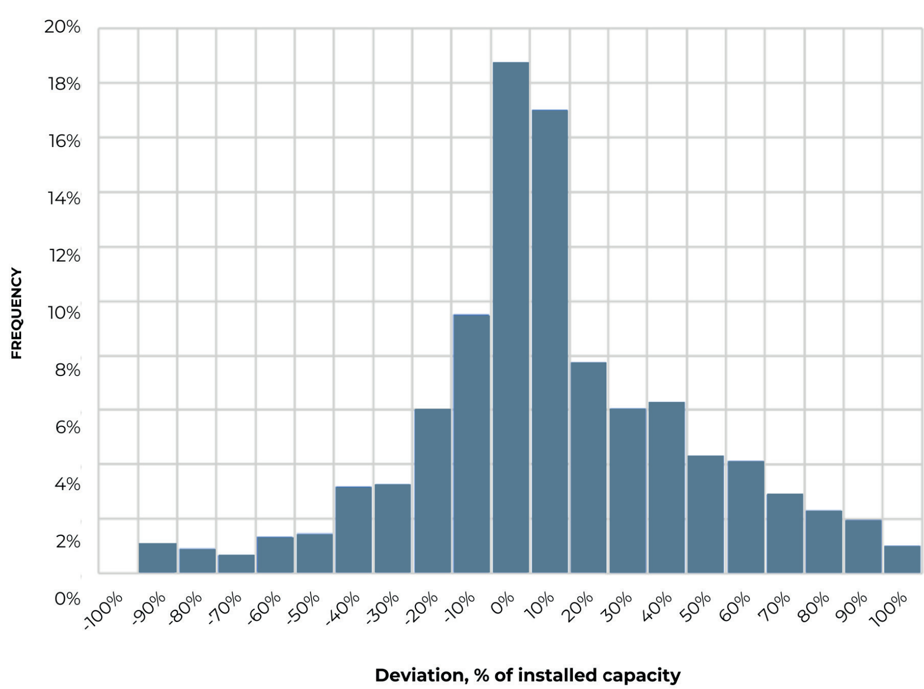
Wind and Solar Power Generation

The most promising application of BESS in combination with renewable energy generation—as part of hybrid groups or qualified conditional consumers—includes the following objectives:

Reducing forecast errors – charging or discharging BESS to ensure compliance with the declared dispatch schedule.

For example, an analysis of annual data on compliance with the planned hourly generation schedule for a 100 MW wind farm commissioned in 2022 showed that 90% of actual deviations from planned values fell within the range of ±60%. At the same time, international experience demonstrates the "learning curve" effect in renewable energy forecasting, meaning that forecast accuracy tends to improve over time as more data is collected.

Figure 7 – Distribution of Deviations between Actual and Planned Generation Values for a 100 MW Wind Farm Over One Year.



Reducing Renewable Energy Curtailment

Preliminary modeling of Kazakhstan's energy system for 2030 suggests that substantial curtailment of renewable generation may be necessary to prevent electricity surpluses and ensure grid stability. BESS can help by storing excess energy and releasing it during peak demand or power shortages.

Power Grids

- Transmission Line Unloading and Upgrade Deferral. BESS can reduce the load on transmission lines during peak demand or generation periods, thereby extending the lifespan of existing infrastructure and enhancing grid reliability.
- Emergency Management. BESS enables rapid response to power imbalances, helping to prevent system failures. It also facilitates and accelerates grid restoration in case of emergencies.

Grid Support Services

Thanks to its high responsiveness, scalability, and flexibility, BESS can be considered for providing grid support services, including:

- Power Flow Management. Kazakhstan's power system operates an Automatic Frequency and Power Regulation system (AFPRS), which continuously monitors the generation-consumption balance and power flows across key National Power Grid sections (including the North-South transit) and interconnections with neighboring systems. BESS can be deployed to correct power imbalances and adjust cross-border power exchanges at the request of the System Operator, ensuring compliance with established limits.
- Emergency reserve – BESS supplying temporary reserves to compensate for energy deficits or excesses.
- Inertia and frequency regulation - traditionally, large synchronous generators at thermal and hydroelectric power plants serve as sources of inertia. However, as the share of renewables grows in Kazakhstan, there is an increasing need for new approaches to maintaining inertia. Grid-forming BESS, utilizing synthetic inertia control algorithms, can adjust power output in response to frequency changes, providing an inertial response similar to that of traditional generators.
- Voltage regulation and network loss optimization – BESS can function as both a source and consumer of reactive power, enabling voltage regulation in both normal and post-fault conditions without the need for additional equipment;
- Reliability enhancement (system adequacy) – BESS can help minimize the risk of power shortages and supply disruptions.
- Black start capability – Kazakhstan's power system spans vast areas with remote regions and an extensive transmission network. In the event of system-wide failures causing mass disconnections of consumers and generation, grid-forming BESS can enable rapid power restoration, minimizing economic losses and social impact.

2. The System Operator's Vision for the Development of Battery Energy Storage Systems (BESS) in the Republic of Kazakhstan

The System Operator proposes the implementation of BESS projects through capacity market auctions and/or arbitrage on the day-ahead and balancing electricity markets.

Investment returns through capacity market auctions offer the following advantages and disadvantages:

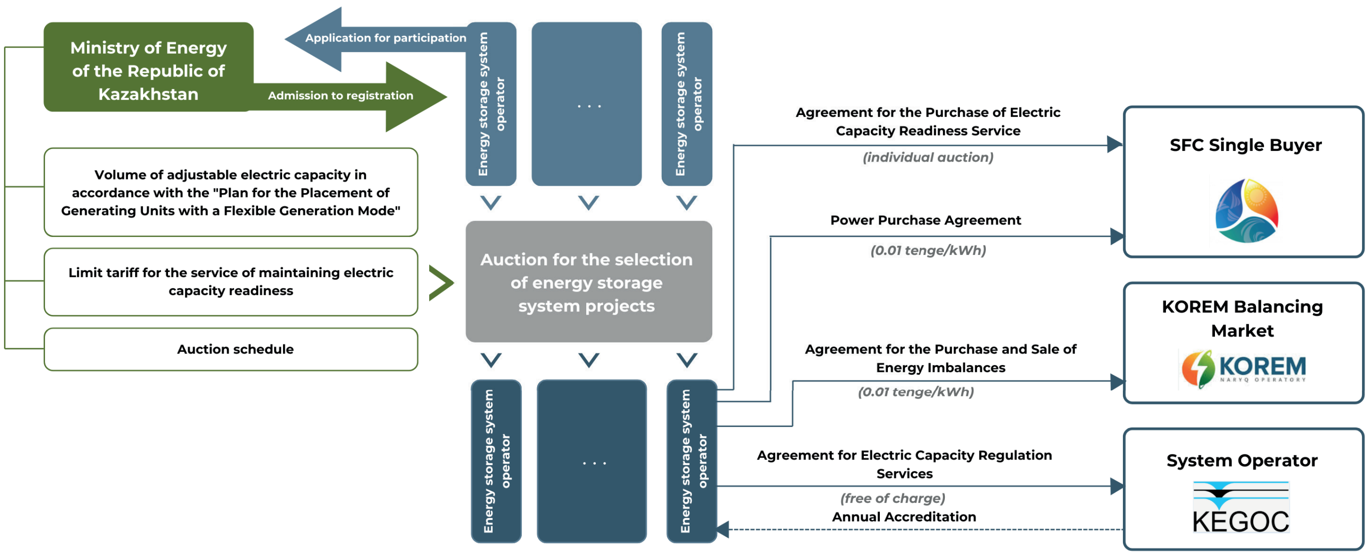
Advantages:

- For the investor – Guaranteed return on investment if selected.
- For the system operator – Free use of BESS for providing system services.

Disadvantages:

- Lack of motivation to improve the efficiency of BESS utilization.
- Limited profit potential.

Figure 8 – Implementation of BESS projects through capacity market auctions (System Operator's vision)



Investment return through arbitrage on the day-ahead or balancing markets has the following advantages and disadvantages:

Advantages:

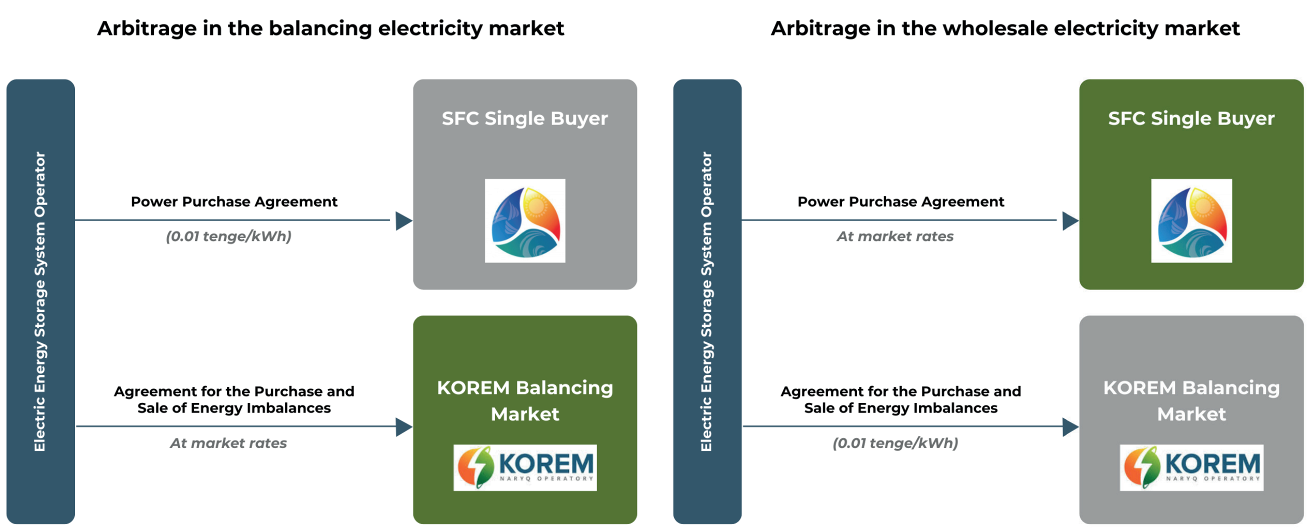
- The responsibility for improving BESS efficiency lies with the owner;
- The ability to use BESS to reduce both local and system-wide constraints.

Disadvantages:

- Lack of investment return guarantees, dependence on market conditions and forecasting quality;
- The need for clear separation of BESS power and capacity for participation in the wholesale and balancing electricity markets.

Inability to sell a day ahead on the wholesale market while simultaneously participating in the balancing market.

Figure 9 – Implementation of BESS projects through arbitrage in the wholesale (day-ahead) or balancing electricity markets (System Operator's vision).



2.2. Battery Energy Storage Systems (BESS) in the Context of Modeling the Development of the Unified Energy System of the Republic of Kazakhstan (Forecast Balance).

The modeling of BESS operation was carried out based on the following initial positions:

Planned Energy Development for 2030 in Accordance with:

- The Forecast Energy Balance of the Republic of Kazakhstan until 2035 (Order of the Ministry of Energy of the Republic of Kazakhstan No. 44 dated January 30, 2023);
- The Auction Schedule for 2024-2027 (Order of the Ministry of Energy No. 187 dated May 23, 2023);
- The Action Plan for the Development of the Electric Power Industry of the Republic of Kazakhstan until 2035 (Order of the Ministry of Energy No. 71 dated February 20, 2024).

Modeling of Power Plant Dispatching in Accordance with:

- For Thermal Power Plants (TPP): Technical minimum/maximum, ramp-up/ramp-down rates.
- For RES – generation profile.

The prospective hourly load was obtained by scaling the reported load profile to the forecasted peak load levels;

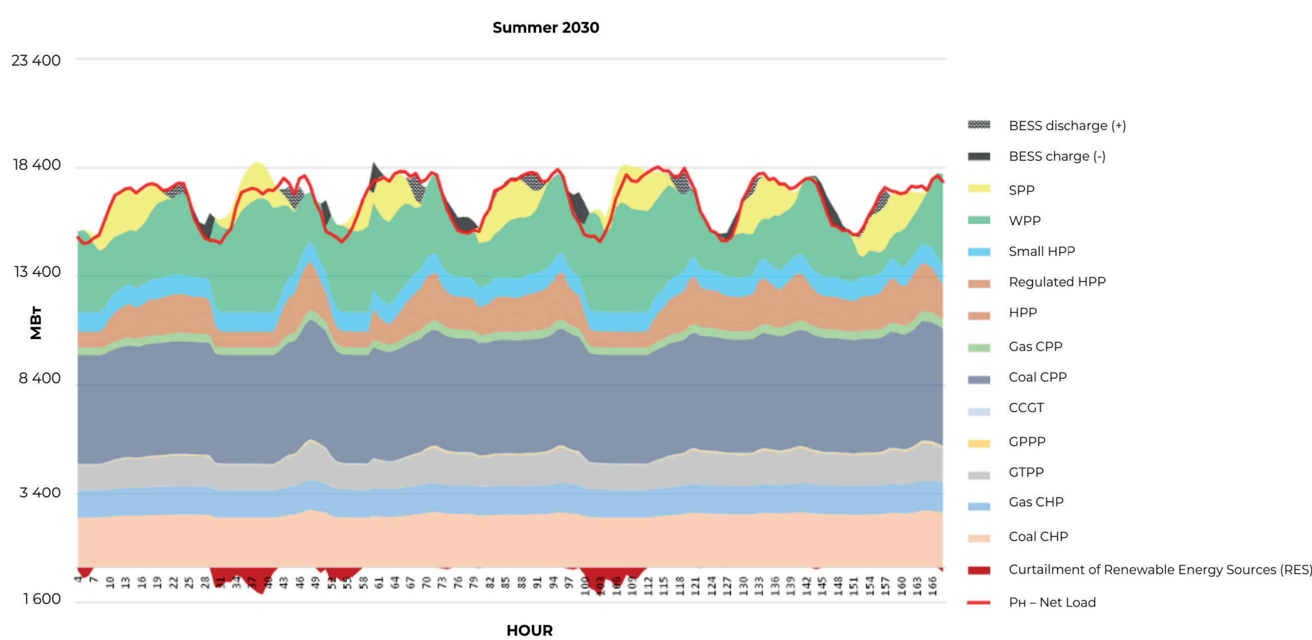
Given the existing contractual obligations on permissible ranges of cross-border power flows, the export/import range for the Unified Energy System of Kazakhstan is set at ±150 MW for the forecast period.

BESS under consideration:

- 300 MW / 600 MWh Total Wind Farm;
- 300 MW / 600 MWh ACWA Power Wind Farm;
- 300 MW / 600 MWh Masdar Wind Farm;
- 300 MW / 600 MWh Shelek Wind Farm;
- 300 MW / 600 MWh China Power Wind Farm.

The principle of BESS operation involves participation in the AFPRS of Kazakhstan's Unified Power System, including regulating power flows through the North-South transit and intergovernmental connections.

Figure 10 – Simulation results of the Kazakhstan's energy system operation with BESS in 2030 (Summer)



The analysis of the planned energy development for 2030 has shown that the Unified Energy System (UES) of Kazakhstan is expected to face a shortage of flexible generation (ramp down capability), which may lead to increased curtailment of renewable energy sources (RES). Reasons for RES curtailment in the model are the following:

1) Overall generation surplus in the power system when the load of conventional power plants is reduced to the technological minimum (shutdown of power plants was not considered). RES curtailment is applied to balance the power system while maintaining contractual levels of cross-border power flows.

2) Overload of the North-South transmission corridor. If an overload occurs in the northward direction, restrictions are applied to RES in the Southern zone, while in the southward direction, restrictions are applied to power plants in the Northern zone.

Resolving the issue of excessive generation expansion in the future will enhance the effectiveness of BESS in reducing RES curtailment.

3. Key Issues and Concerns

- The effective use of BESS requires consideration of the specific characteristics and operational features of Kazakhstan to determine the feasibility and potential for implementation in various scenarios;
- Under the existing market conditions, BESS can be utilized both as a standalone solution and as part of projects in electricity generation, transmission, and consumption;
- The system operator is considering the implementation of energy storage systems through competitive selection in the capacity market or by utilizing arbitrage strategies in the day-ahead wholesale and balancing electricity markets, as well as in the ancillary services market.
- Given the planned generation expansion by 2030, a shortage of downward capacity reserves is expected, leading to increased curtailment of renewable energy sources.
- Resolving the issue of excessive generation expansion in the future will enhance the effectiveness of BESS in reducing RES curtailment.

DEVELOPMENT OF ENERGY STORAGE SYSTEMS: REGULATORY FRAMEWORK

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Member of the Board of Directors of the Qazaq Green RES Association

AMENDMENTS TO THE CURRENT LEGISLATION GOVERNING THE ESS

The legal basis for regulating the issues related to the ESS has become the adoption in 2024 of a number of regulatory legal acts in particular the Law of the Republic of Kazakhstan dated July 8, 2024 No. 121-VII "On amendments to some legislative acts of the RK in the issues of heat power, electric power and regulative services" according to which the concept of energy storage systems was introduced into the Law of the RK "On support of the utilization of renewable energy sources" and the possibility of conducting the auction selling for the selection of projects for the construction of new facilities on the utilization of renewable energy sources equipped with ESS. In addition, the Order of the Minister of Energy of the Republic of Kazakhstan dated October 14, 2024 No. 367 "On Amendments and additions to certain Orders of the Minister of Energy of the Republic of Kazakhstan" was adopted, according to which additions were made to the electric grid rules and rules for the technical operation of electric power plants and networks, which lay down the basic parameters and principles of operation of ESS within the energy system.

Despite the fact that the adoption of these amendments is the first step in the development of the ESS and acts as a positive signal for the sector, some of the adopted standards are likely to require adjustments.

Thus, according to paragraphs 4 and 9 of the electric grid rules for energy-producing organizations with a declared electric capacity of 5 MW, the condition for connecting to the electric grid is the development of a scheme for power output to a power plant and meeting the requirements of the technical specifications of the energy transmission organization in accordance with the developed scheme for power output.

At the same time, the above-mentioned order, among other things, made additions to the electric grid rules on the content of the scheme for power output to a power plant (Appendix No. 3), in particular, the following items are included:

"…

2-1) the volume of annual available capacity and capacity of electric energy storage systems, taking into account the compensation of degradation of electrochemical electric energy storage systems;

2-2) annual availability coefficient of electric energy storage systems;

…

15) technical characteristics of electric energy storage systems specified by the instructions of the manufacturers, including the response time, the number of cycles of accumulation (charge) of output (discharge) of electric power per day, month, year.".

Based on the literal interpretation of the legislation, the amendments imply that all energy-producing organizations, and primarily energy-producing organizations using renewable energy sources, are required to install renewable energy sources at power plants.

The issue of the need to provide renewable energy facilities is conditioned by the need for stable operation of the energy system in the context of an increase in renewable energy generation, that is, a balance must be maintained between achieving the share of renewable energy in generation and the stability of the energy system.

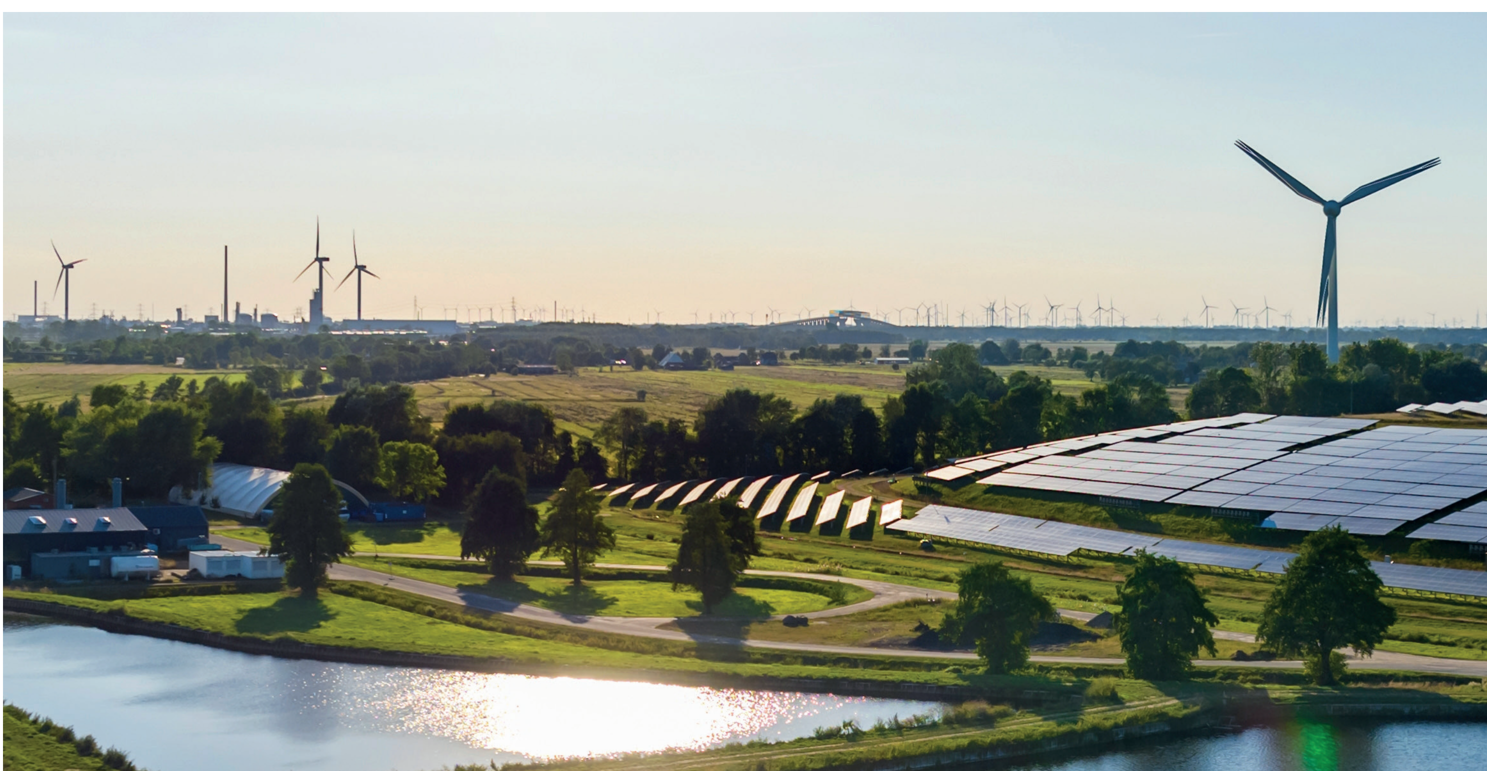
However, this approach seems controversial for a number of reasons, primarily with the introduction of a real-time balancing electric power market in July 2023, after which energy-producing organizations using the RES that have concluded a long-term agreement with the SFC after July 1, 2023 or do not have such a long-term agreement should be responsible for deviations from planned generation.

However, this approach seems controversial for a number of reasons, primarily with the introduction of a real-time balancing electric power market in July 2023, after which energy-producing organizations using the RES that have concluded a long-term agreement with the SFC after July 1, 2023 or do not have such a long-term agreement should be responsible for deviations from planned generation. Another aspect is the fact that deviations of energy-producing organizations using renewable energy sources can be compensated through other tools, for example, the implementation of a backup maneuverable generation project together or combining the RES with maneuverable generation under one balance provider. In other words, the legislation already encourages energy-producing organizations using RES to reduce generation deviations, and new amendments to the grid rules deprive energy-producing organizations using renewable energy sources of the right to choose which tools to achieve greater generation st ability.

In this regard, it is believed that the electric grid rules should be revised in terms of excluding the provisions concerning the mandatory availability of the ESS from the content of the power output scheme to the power plant. An alternative option may be to make a reservation that the provisions relating to the ESS are included in the scheme for power output to a power plant in the absence of other options for compensating for generation deviations.

Another area of work to change the current legislation governing the ESS in the future should be the revision of the parameters and requirements for ESS, taking into account the operation of ESS in the real conditions of the energy system, as well as taking into account the development of technologies in the field of ESS.

A separate study requires the issue of distinguishing the regulation and requirements for large ESSs operating in the wholesale electric power market and low-power ESSs that will be used in the retail electric power market. For low-power ESS, regulation should be as simplified as possible and aimed only at eliminating negative impacts on power distribution networks and the safety of consumers themselves in the retail market.



GENERAL CHANGES IN CURRENT LEGISLATION

To ensure proper legal regulation of relations connected to the implementation of the ESS projects, first of all, it is necessary to form a conceptual framework.

In addition to the definition of the ESS introduced by the Law of the Republic of Kazakhstan dated July 8, 2024 No. 121-VIII "On amendments and additions to certain legislative acts of the Republic of Kazakhstan on thermal energy, electric power industry and regulated services" to the Law of the Republic of Kazakhstan "On support for the use of renewable energy sources" this concept should be included in the Law of the Republic of Kazakhstan "On Electric Power Industry", as well as subordinate regulatory legal acts aimed at regulating the ESS. Similarly, in order to consolidate the legal status of persons owning or managing ESS, it will be necessary to establish a term denoting the operating organization/ESS operator reflecting the functions of buying and selling electric power. The composition of the subjects of the wholesale electric power market is also subject to change by including operating organizations/ESS operators. In order to implement the above recommendation on the differentiation of low-power ESS, the term low-power ESS should be provided for in legislation with the establishment of appropriate criteria for classification as such.

Currently, legislation provides for various types of activities in the field of electric power industry, including the production, transmission, distribution, and consumption of electric power. Taking into account the specifics of the ESS, it is necessary to provide for new types of activities in the Law of the Republic of Kazakhstan "On Electric Power Industry", as well as subordinate regulatory legal acts regulating the ESS, namely the accumulation and storage of electric power.

Also, in order to increase the investment attractiveness of projects using the ESS, it is proposed to include activities related to the accumulation and storage of electric power in the list of priority activities that will be subject to investment preferences provided for by the Business Code of the Republic of Kazakhstan, such as exemption from import customs duties, payment of value added tax, provision of a government land grant, etc. In this regard, it will be necessary to make changes and additions to the list of priority activities approved by the Resolution of the Government of the Republic of Kazakhstan dated January 14, 2016 No. 13 and the General Classifier of Economic Activities of the National Tax Code of the Republic of Kazakhstan 03-2019 approved by the Committee for Technical Regulation and Metrology of the Ministry of Trade and Integration of the Republic of Kazakhstan.

CHANGES IN INDIVIDUAL LEGAL MECHANISMS FOR THE IMPLEMENTATION OF BATTERY ENERGY STORAGE SYSTEMS (BESS) PROJECTS

RES AUCTIONS WITH STORAGE DEVICES

As mentioned above, the Law of the Republic of Kazakhstan "On Support for the use of renewable energy sources" provides for the possibility of holding auctions for the selection of projects for the construction of new renewable energy facilities equipped with ESSs.

At the same time, for successful auctions and the implementation of such projects, it is necessary to take into account the specifics of renewable energy facilities equipped with ESS, in terms of the fact that long-term contracts with the SFC are concluded for a period of 20 years, while the service life of the ESS (taking into account constant degradation) is much shorter. Accordingly, during the period of validity of the long-term ESS agreement, facilities for the use of renewable energy sources will be fully renovated. In addition, equipping the renewable energy facilities with ESS will lead to a significant increase in the cost of projects.

In this regard, it will be necessary to take into account the above specifics in the tariff setting of renewable energy facilities equipped with ESS. Taking into account the degradation of ESS and the need to update them during the long-term contract with the SFC, as well as taking into account the variability of market prices for ESS, it is proposed to consider the possibility of setting tariffs (auction prices) for renewable energy facilities equipped with ESS, consisting of two parts. The first part will relate to payback and profitability for the facility as a whole (excluding ESS), and the second one is to only affect the ESS. At the same time, by the time it becomes necessary to update the ESS, the second part must be revised (while keeping the first part of the tariff unchanged), taking into account the costs that will arise by the time the ESS is renewed.

The implementation of such a mechanism will require amendments and additions to the Law of the Republic of Kazakhstan “On Support for the use of renewable energy sources” in terms of the tariff (auction price) of renewable energy facilities equipped with ESS consisting of two parts and the establishment of general requirements for the procedure for reviewing the second part of the tariff with the consolidation of a detailed mechanism at the level of rules for the centralized purchase and sale of electric power a single buyer of electric power produced by facilities for the use of renewable energy sources, facilities for energy waste disposal (approved by Order of the Minister of Energy of the Republic of Kazakhstan dated March 2, 2015 No. 164).

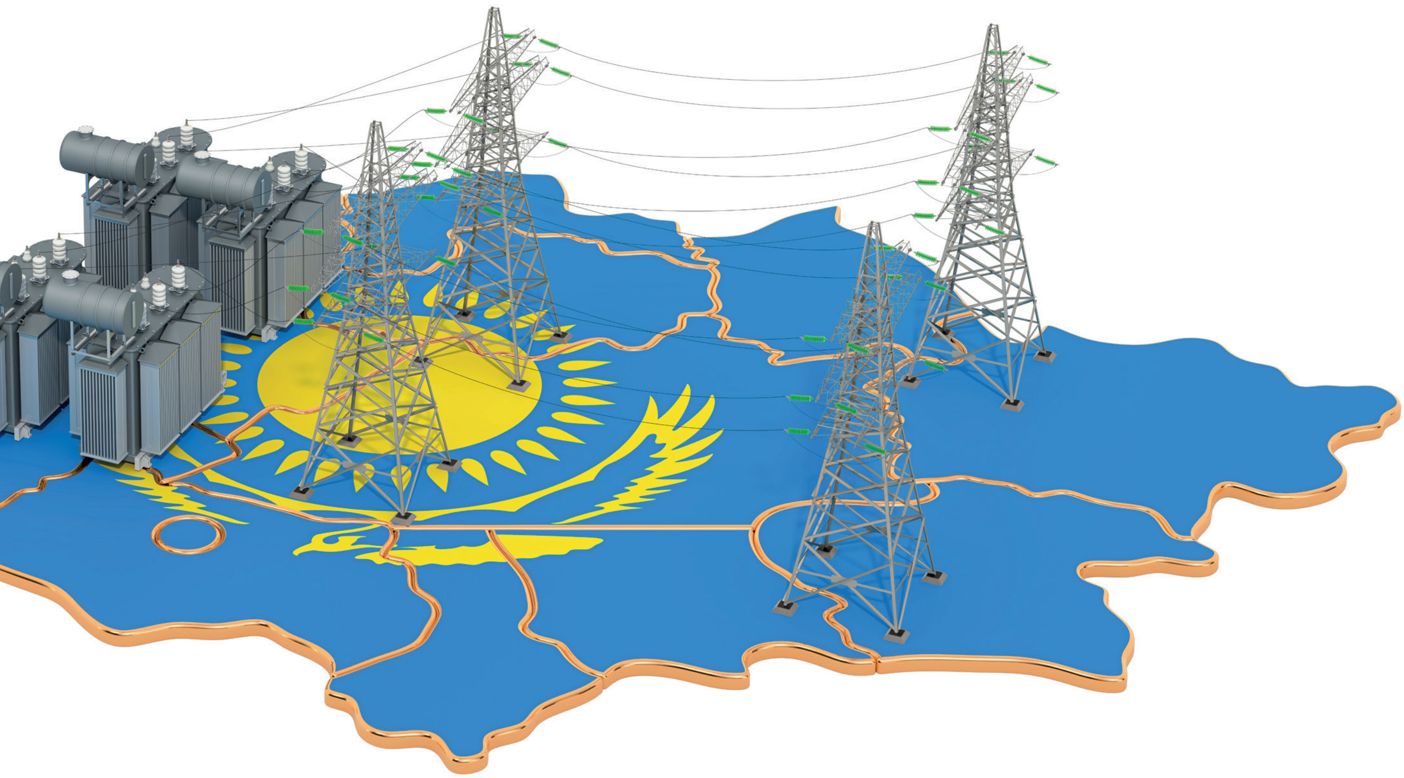
In addition, given the increased cost of projects due to the need to install the ESS, it is likely that the Order of the Minister of Energy of the Republic of Kazakhstan dated January 30, 2018 No. 33 "On approval of maximum auction prices" will need to be revised.

PRICE ARBITRATION

This mechanism for implementing ESS projects, when the return on investment and profit is achieved through the difference in the purchase and sale price of electric power, seems to be the most market-oriented (without priority purchase of electric power/capacity), in this regard, legislative regulation should be minimal and, accordingly, no significant number of amendments and additions to legislation are required. The legal principle of “everything that is not explicitly prohibited by law” should be applied as much as possible in the regulation of the ESS projects implemented under this mechanism.

In this regard, it will be necessary to take into account the above specifics in the tariff setting of renewable energy facilities equipped with ESS.

At the same time, in order to attract potential investors, we consider it possible to provide in the Law of the Republic of Kazakhstan “On Electric Power Industry” a formal mention that ESS projects can be implemented on their own initiative (through the mechanisms of auctions of RES or on the electric capacity market) with the possibility of participation on a common basis in the wholesale electric power market, in the balancing electric power market (including within the framework of the balance provider), with the right to conclude a power control agreement with the system operator, etc. An analogy in this case may be the Law of the Republic of Kazakhstan “On support for the use of renewable energy sources", which in paragraph 1 of Article 9 provides that RES projects can be implemented both through the mechanism of centralized sale of electric power to the SFC and on the basis of free bilateral agreements with consumers.



Historically, the regulatory framework for electric power has not been created taking into account technologies such as electric power storage. This has led to a lack of legal clarity regarding its definition. BESS is often considered as a component of power generation and, as a result, is subject to the same requirements/ licensing/permits/network fees as traditional generating units. However, it is also a consumer subject to network charges (during charging), and this dual characteristic of BESS creates ambiguity in its legal definition and thus creates a barrier to its deployment. It is important that legislative regulation avoids double charging of network fees for BESS, as this will create a significant barrier to building an economic case for stand-alone BESS projects.

Also, a controversial issue regarding the ESS projects implemented under this mechanism is the consolidation in the legislation of the authority of the Ministry of Energy to prescribe the maximum spread, i.e. the marginal difference between the purchase and sale price of electric power by ESS operators. The argument for the establishment of such competence of the Ministry of Energy is the ability to influence pricing and limit the possible receipt of excess profits by ESS operators. However, from the point of view of potential investors planning to implement projects on market terms (without guaranteed return on investment), such a restriction will act as a deterrent.

AN AUCTION FOR THE CONSTRUCTION OF AN ESS IN THE FRAMEWORK OF THE ELECTRIC CAPACITY MARKET

The selection of ESS projects within the framework of the electric capacity market through the auction mechanism seems to be the most effective, capable of attracting strong investors with competitive capacity tariffs.

At the same time, an electric power storage system is understood as an electrical installation designed for the accumulation, storage and delivery of electric power, with an automated control system, interconnected structures and infrastructure that are technologically necessary for their operation.

In this scheme, it is necessary to introduce the concept of an operator of an electric power storage system – an organization that purchases electric power and subsequently sells it through the ownership and (or) management of an electric power storage system. At the same time, the operator of the electric power storage system must be defined as a subject of the wholesale electric power market, with all its rights and obligations.

Unlike other subjects of the wholesale market – consumers of electric power, operators of the electric power storage system do not form forecast consumption requests, and their electric consumption capacity is not taken into account in the projected demand for electric capacity.

Since the operator will purchase grid electric power from different energy sources at different times of the day, and then supply it to the grid under the control of the system operator, it is necessary to determine price arbitration for electric power. In this regard, the authorized body needs to determine the procedure for determining the difference in the cost of purchased and sold electric power by the operator of the electric power storage system.

It is necessary to legally oblige the unhindered access of ESS to the networks of energy transmission organizations.

The mandatory requirements for the ESS will be the availability of an ACEMS, a telecommunications system and an ALFC connection.

When organizing ESS auctions, the authorized body, together with the SO in the auction schedule, must determine the locations of the ESS, with connection points, as well as the marginal cost per unit of capacity. The auction organizer needs to calculate the technical requirements for each individual site, which will differ from the location of the ESS in the energy system.

As part of the auction for electric power, it is necessary to develop requirements for the operation of the ESS, the number of charges/discharges, and other requirements that may affect the economics of ESS construction and operation projects. As a suggestion, we suggest considering the possibility of determining the number of charges/discharges - 400 cycles per year.

The winner of the auction has the opportunity to sign a contract with a Single buyer for the purchase of services to maintain the availability of electrical power. Power suppliers receive payment for their existing capacity (tenge/MW) and energy supplied to the grid (tenge/MWh) as requests are received from the system operator.

The BESS systems in the capacity market can earn income from the energy arbitrage mechanism, but in this case, they must always maintain a minimum capacity reserve if they are involved in the capacity market.

The contractual electrical capacity of electric power storage systems is subject to annual certification by the system operator from the date of their commissioning.

If, as a result of the next certification of electric power (capacity), the value of the certified electric power (capacity) turns out to be less than the volume of services specified in the contract with a Single buyer, the volume of services for maintaining the availability of electric power, taken into account when calculating the actual services provided for maintaining the availability of electric power, is reduced to the certified value before the next attestations.

During the operation of the ESS, penalty coefficients will be applied to the ESS Operator, in case of unavailability of the certified power (capacity) of the ESS, and in the case of SO, if the number of charges/discharges specified in the contract is exceeded.

This mechanism carries risks of uncertainty for investors related to vague conditions of participation in the capacity market and weak administration.

The mechanism of operation of the ESS in the capacity market requires changes both to the law on the Electric Power Industry and to the RLA, in particular to the PTE, Auction Rules, Electric grid regulations, etc.

IMPLEMENTATION OF THE ESS PROJECTS BY A SYSTEM OPERATOR THROUGH SYSTEM SERVICES

The system operator is one of the key actors within the energy system and performs many functions, including providing system services such as transmission of electric power through the national electric grid, use of the national electric grid, technical dispatching services, balancing of production and consumption of electric power, etc.

In this regard, the implementation of ESS projects can be carried out within the framework of the above-mentioned system services, primarily services for balancing the production and consumption of electric power with reimbursement of the costs of the system operator through the appropriate tariff.

This approach can become one of the most effective, since the system operator, by virtue of its functions, is interested in stable and reliable operation of the power system and, accordingly, by independently implementing the ESS projects, will be able to use their potential most effectively[1].

The electric power production-consumption balancing service involves organizing the functioning of a balancing electric power market in real time and is regulated by various regulatory legal acts, primarily the Laws of the Republic of Kazakhstan “On Electric Power Industry”, “On Natural Monopolies” and the rules for tariff formation (approved by Order of the Minister of National Economy of the Republic of Kazakhstan dated November 19, 2019 No. 90).

The determination of the tariff of the system operator for the balancing service of production and consumption of electric power is generally subject to the general procedure for the formation of tariffs for all subjects of natural monopolies and consists in the return of funds spent on the provision of services through the tariff. The current legislation does not explicitly prohibit the system operator from implementing ESS projects at the expense of the tariff for balancing the production and consumption of electric power. However, given the law enforcement practice, when the Committee for Regulation of Natural Monopolies and its territorial divisions approving tariffs of natural monopoly entities pursue a policy aimed at curbing tariffs and taking into account that the ESS projects are a new sector for the energy system, there are risks of not including the costs of implementing ESS projects in the system operator's tariff for balancing production and consumption of electric power.

To reduce this risk, it seems advisable to consolidate at the level of the Law of the Republic of Kazakhstan “On

Electric Power Industry" and the rules for tariff formation special provisions stipulating that during periods of shortage of regulating capacity in the energy system, according to the projected balance of electric power and capacity (annually approved by the Ministry of Energy for 7 years), the costs of the system operator for the implementation of the ESS projects are included in the tariff for balancing services production-consumption of electric power in a priority order.

THE ESS PROJECTS IN THE RETAIL MARKET "BEHIND THE COUNTER"

Currently and in the medium term, in conditions of a high level of depreciation of the grid economy and a tendency to annual tariff increases, the use of ESS in the retail electric power market may become a promising area. First of all, this applies to small and medium-sized businesses, net consumers of electric power, but it is also possible to use it in households.

In addition to the obvious positive effect of increasing the reliability of electric power supply and ensuring greater energy independence of consumers, economic incentives must be created for the development of this segment.

Currently, in the retail electric power market, tariffs of power supply organizations are regulated as a sphere of socially significant markets in accordance with the Business Code of the Republic of Kazakhstan, tariff formation is determined by the Rules of Pricing in socially significant markets. Tariffs in the retail electric power market are differentiated by consumer groups and consumption volumes, but under equal conditions (one group of consumers and one volume of consumption), the price is the same. In this regard, in addition to the indicated differentiation, it is also necessary to establish a differentiation of tariffs by zones of the day, that is, at different times the cost of electric power will differ. In general, this approach will correspond in a simplified form to the change in the cost of electric power in the wholesale market (where the price of a single buyer varies every hour).

The correct application of the tariff differentiation mechanism by zones of the day in the retail electric power market, in addition to becoming a tool for the sale of the ESS, will have a generally positive impact on the energy system, as it will help smooth peak loads, align consumption schedules and improve operational stability.

It should be noted that the differentiation of tariffs in the retail market by zones of the day is not a completely new tool. Thus, the current rules for differentiating electric power tariffs by power supply organizations depending on the volume of its consumption by individuals (approved by the Order of the Chairman of the Agency for Regulation of Natural Monopolies of the Republic of Kazakhstan dated February 20, 2009 No. 57-OD) until 2017, in addition to consumption volumes, also provided for differentiation by zones of the day. During this period, two- and three-zone consumption (differentiation) systems were provided with the establishment of periods of morning and evening highs, as well as daytime and nighttime dips. We believe that the rejection of this system was erroneous and was caused by incorrect planning and administration of the process, as well as the lack of flexibility of the tariff setting system in the retail electric power market (energy supply companies either suffered losses or received excess profits) and the timing of tariff adjustments. An important aspect is the fact that, from a technical point of view, there are no significant problematic issues for the implementation of the reform, since the vast majority of consumer metering devices allow accounting for consumed electric power at differentiated tariffs by zones of the day.

A significant issue that needs to be resolved is the distortion of pricing in the retail electric power market due to the application of the above differentiation by consumer groups. For example, as of December 31, 2024, in the city of Karaganda, the consumers, depending on the group, purchase electric power at the following tariffs (per 1 kWh excluding VAT):

1) household consumers – 19.91 tenge;
2) non-household consumers (legal entities) - 33.51 tenge;
3) budget organizations – 89.80 tenge.

Such a significant gap in tariffs is non-market in nature, in contrast to the differentiation of tariffs by day zones, where tariffs will be formed taking into account supply and demand in the retail electric power market and contribute to the introduction of ESS.

> **Tariffs in the retail electric power market are differentiated by consumer groups and consumption volumes, but under equal conditions (one group of consumers and one volume of consumption), the price is the same.**

To implement the above mechanism, minor amendments will be required to the Law of the Republic of Kazakhstan "On Electric Power Industry" in terms of consolidating the described type of differentiation and the relevant competence of the authorized body for the development of differentiation rules, amendments to Pricing Rules in socially significant markets regarding the exclusion of tariff differentiation by consumer groups, as well as the development of separate rules for tariff differentiation in the retail electric power market by zones of the day.

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[1] The system operator's right to implement ESS as part of its balancing service can act as a temporary measure for 3-5 years while Kazakhstan's energy system is experiencing great difficulties in the absence of sufficient regulatory capacity.

saft

Battery Energy Storage systems are key to power systems' efficiency and resilience

Meeting the net-zero targets established by many countries requires, in most modern power systems, a substantial increase in the use of renewable energies, mostly wind and solar. The growing penetration of variable, non-dispatchable renewable generation not only increases the need for system flexibilities to balance the variations of demand and supply, it also raises the need for capacity reserves to guarantee supply security for several hours, particularly during peak demand or contingency situations. Furthermore, it poses challenges for our electricity grids, both in terms of operational management and grid stability. In short, both the need for flexibilities and for capacity reserves is heightened due to the lower predictability and dispatchability of renewables.

Traditionally, flexibility and capacity reserves are provided by fast-reacting resources like Combined Cycle Gas Turbines (CCGT).

Battery Energy Storage Systems (BESS) offer a greener replacement to this fossil-fuel based resource. Whilst their role was mainly focused on ancillary services in the early days, today's state-of-the-art BESS are designed to stack multiple functions over different time constants, helping

1- to balance supply and demand,

2- to ensure security of supply, and

3- to optimize grid management and guarantee grid capacity and stability.

As we all work towards Net Zero[1], they play a critical role in capturing and valuing precious zero-carbon electricity which otherwise risks being curtailed -at an economic and environmental cost- and to substitute vital, but currently fossil-fuel based flexibility and capacity resources.

Battery storage is becoming increasingly competitive delivering peak power at a cost similar to gas peakers. In the USA, tenders have already been awarded to ESS rather than gas peaking. In the EU, because energy costs have increased, any battery storage-based function is now a more profitable venture than it was before.

ENERGY SHIFTING WITH ESS

The major role of storage therefore consists of absorbing renewable energy when produced in excess of consumption or in excess of the transmission capacity of the grids, and to inject this energy to the grid when needed, with arbitrage as the predominant remuneration mechanism. This function is technically described as "energy shifting", typically realized with 2-hour to 4-hour storage systems, with a trend to longer discharge durations. Most systems operate in a daily charge/discharge scheme (e.g. charging solar energy during daylight hours and discharging during evening hours), but some go up to the equivalent of two discharge cycles per day.

The predominant remuneration model for BESS is storing electricity in periods of abundant production and low market prices, and selling electricity when prices are high, typically during early evening peaks. This operation can be directly coupled to a wind or solar generator, in which case the operator simply delays selling a portion of his production to periods of higher market prices – the prevailing operation and revenue generation model in the USA driven by tax incentives installed by the US Inflation Reduction Act (IRA). The BESS can also be operated as a "standalone" asset, absorbing and storing energy from the grid and re-injecting energy back to the grid. In this case, arbitrage is usually combined with other ancillary services (i.e. primary and secondary frequency regulation) – the predominant remuneration model in Europe.

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[1] Net Zero : ref United Nation Climate actions

The value generation is enhanced when it comes to curtailment avoidance: not only, the energy is valued at market prices instead of being lost, but additional savings are realized by avoiding substitution costs and, possibly, grid enhancements. Currently we see a steady increase of curtailed renewable energy, which is lost for the community at a relatively high and continually increasing- economic and environmental cost.

However, such remuneration mechanisms are based on merchant markets, and hence exposed to market price variability, considered as a relatively high risk from the investor's perspective.

SECURITY OF SUPPLY

Especially in Europe the recent energy crisis has revealed the vulnerability of electricity systems in periods of constraints, related to its dependency on (often imported) natural gaz. We now see capacity markets being created in many countries to ensure electricity is available at an affordable cost even during infrequent peak periods (e.g. cold winter evenings) and contingency situations. The typical required duration for capacity markets is 2 hours, again with a trend to increase towards longer time periods.

Capacity markets are an interesting revenue adder for storage operators, as contracts are signed for multi-year periods with usually stable prices ensuring a secure and predictable income for investors.

GRID SERVICES

Besides the a.m. balancing and security of supply functions, the contribution and competitiveness of BESS in frequency regulation and voltage support ancillary services is well established and used by transmission and distribution grid operators as a lifeline to ensure voltage and frequency stability of the power systems. BESS have reached significant shares on frequency regulation markets in several countries.

However, the ever-increasing penetration of variable renewable sources (wind, solar) brings new challenges to grid operators, in particular problems of grid congestions as well as grid stability and resilience.

However, the ever-increasing penetration of variable renewable sources (wind, solar) brings new challenges to grid operators, in particular problems of grid congestions as well as grid stability and resilience.

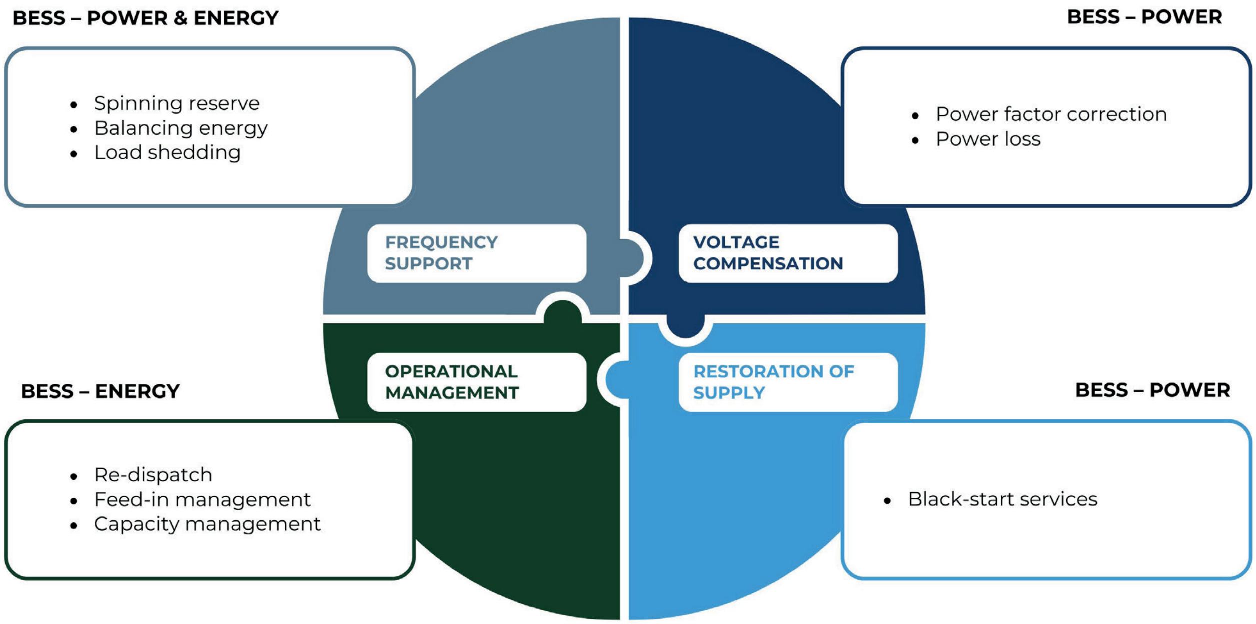
Grid congestions are linked to the different locational distribution of wind and solar generators, much more distributed compared to conventional power plants, yet with "hot spots" of renewable generation in places not foreseen in the grid topology. A prominent example is the massive generation of wind energy in Germany's norther coastal area, challenging grid operators to transport energy to the southern regions where most power-hungry industries are located. In the short run, this situation leads to curtailments and increasing cost for dispatch management and feed-in management. For example, curtailment of renewable energies has reached 9.3 TWh in Germany in 2024, up 50% from 2021 levels and equalling 3% of the country's renewable generation.

Grid stability can be threatened by the reduction of dispatchable base generation -typically large-scale synchronous generators- and the subsequent increase of asynchronous renewable energy plants which are connected by inverter-based technologies. This substitution process not only reduces the operator's flexibility in dispatch management, it also leads to a reduction of inertia of the grid, making it more vulnerable to sudden power fluctuations, outages or other unpredictable incidents. A lack of inertia can lead to a very fast collapse of grid frequency in case a major generation plant or transmission line is lost.

State-of -the art BESS offers technically sound solutions to address various problems in a single solution. They can support four fundamental areas of grid management typically under the responsibility of Transmission System Operators (TSO's):

- Frequency support services: in addition to existing primary and secondary frequency regulation, BESS can offer inertia support combining grid forming capability of inverters with the ability to inject active power within milliseconds.
- Operational management services: they address the 3C's: Congestion, Curtailment and Capacity reserve. They can temporarily relieve transmission lines by storing energy ahead of grid bottlenecks, thus avoiding curtailments. BESS can either substitute or complement other technologies implemented by TSO's, such as DLR (Dynamic Line Rating) and Power flow control.
- Voltage compensation services: they can be supplied by BESS both at distribution and transmission levels, avoiding the need for CAPEX intensive solutions. Their ability to provide power factor correction and to inject active power enables BESS to absorb the VAR and keep statutory voltage levels of distribution networks, and to compensate the losses during transit of power voltage compensation in transmission networks.
- Restoration of supply: During black start of a particular network in the grid, batteries can replace expensive fossil-fuelled backup resources. Black-start services are need to re-energize sections of the network after a breakdown.

It is essential to recognize that a single BESS can deliver multiple services, if properly sized and engineered, and well managed in operation. The need for above mentioned services does usually not occur simultaneously, and it is common



practise to "reserve" certain services for given periods of a day, a week or a year. Yet it is technically possible to combine multiple functionalities, e.g. supersede energy shifting with a frequency regulation service. An operational example of this principle can be found in Taiwan (called EdReg).

Remuneration models for frequency regulation (FCR, FRR), capacity services and arbitrage are increasingly well established in many countries. We also see operators include inertia-type services with frequency regulation (eg. FCAS in Australia or Dynamic Containment in the UK). The use of BESS for grid congestion management, however, is still in its early days with regulators trying to define services and remuneration models that enable TSO's and DSO's to outsources such services rather than to own and operate BESS by themselves – an option which is not authorized or not desirable in many jurisdictions. The "Gridboosters" in Germany or "Ringo" demonstrator in France represent early exceptions to this rule. Today, we see the first local flexibility markets emerge in the UK, France Spain or Australia, with a prominent example of the GOPACS congestion management platform in the Netherlands. These remunerate local flexibilities, which can usually be provided by energy storage or demand side management, able to withdraw or to inject power at certain parts of the grid and during certain periods. The value created for the system is based on cost reductions for re-dispaching and curtailment, as well as reduced expenditures on grid re-inforcement and grid stability, such as re-conductoring of existing lines or investments in new lines and other inertial supports.

It is obvious that the value creation of one single service is usually not sufficient to build a sound economic model for the BESS. Application Stacking is becoming current practice today to capture multiple value streams, and to de-risk return on investment by combining merchant and contractual services, and by enabling systems to change operation pattern over the operational life of the BESS to optimize revenue streams. This has a direct impact on the design of BESS, essentially in three areas:

- Energy throughput: to stack multiple services, BESS are increasingly used beyond a single charge-discharge cycle per day. During periods of intensive use, a single battery must be able to sustain multiple charge/discharge cycles at various DOD (depth of discharge), leading to a cumulated throughput of up to 300% per 24h. This puts high requirements on the thermal management system.

- Digitalization is key to supervise BESS remotely and to ensure highest availability, in particular when systems increase in size and when operation patterns are complex, dynamic and changing over time.

- Safety: multi-MW BESS are no longer exclusively destined to remote areas. As we need them to provide local flexibilities, they are increasingly installed in infrastructure- and population-dense areas, as well as behind-the-meter on industrial sites and datacenters. This implies ever increasing levels of safety requirements on BESS and rejection of "let it burn" options in such places.

THE LATEST ESS DEVELOPMENTS

Currently, we are seeing increasing trends in energy density, system architecture and digitalization.

SCALING UP FASTER WITHOUT COMPROMISING SAFETY AND CYBERSECURITY

Today, systems of 100 MW for two hours (200 MWh) or four hours (400 MWh) are commonplace, and we start to see single installations at the gigawatt level. To accommodate this requires more ESS containers. So, installation space is becoming an increasing challenge, knowing that battery containers need to be connected to Power Conversion Systems

(PCS) and Transformers, and be installed at safe distances allowing access for maintenance. So, how do we account for the need to economize space, whilst ensuring the highest levels of safety?

Since the first lithium-ion battery container left Saft factories in 2012, the energy density of a single 20-foot container has increased 10-fold from 500 kWh to 5.1 MWh today. Whilst bigger sizes and densities of lithium-ion cells are enabling such densities, the challenge in engineering lies in developing and qualifying high-performance battery system solutions which can be transported to any place in the world, and to guarantee reliable operation over 15 to 20 year lifetimes, with the highest safety standards, and efficient cooling in minimum space volumes with high energy efficiency.

Saft's latest generation of lithium-ion BESS, called Intensium® Flex, provides 5.1 MWh of storage capacity in standard ISO 20-foot containers. Manufactured under stringent quality controls in our factories, the product has been developed, tested and qualified by in-house engineering teams to integrate

- proprietary control electronics (BMS) from module level to system level. Combined with stringent qualification testing as well as component sourcing in Europe and the US, the control system exceeds industry standards in reliability and cybersecurity.

- a liquid cooling system ensuring temperature homogeneity among all battery modules, under extreme environmental conditions and with high energy efficiency,

- a risk-analysis based safety approach implementing redundant, electronic and physical safety barriers at multiple levels to manage, among others, fire and explosions risks. Saft's safety approach is holistic, anticipating worst-case scenarios at product level, site installation level, and with the operating personnel and fire fighters.

The footprint of a full BESS is also impacted by the size and number of power conversion systems (PCS) needed to convert the DC energy of multiple containers into AC. Saft's control system accurately manages up to eight containers in parallel, i.e. more than 40 MWh can be connected to a single PCS. This allows Saft to design system architectures based on the largest, cost-optimized PCS systems available on the market.

The increased energy density of the container building blocks, combined with advanced controls, sophisticated safety features and a space-saving plug-and-play installation, is game-changing. All in all, this means industry can now deliver utility-scale BESS for up to eight hours of energy shifting, all

while dividing floorspace and installation time by a factor of 2 or 3.

INCREASING DIGITALIZATION

Modern BESS are also becoming increasingly digitalized, enabling real-time system management and the use of Artificial Intelligence and Machine Learning. This improves efficiency while reducing downtime and maintenance costs. Data interfacing with the cloud provides remote monitoring of key performance indicators (KPIs) and control over all operational parameters of their system

With Saft's I-Sight system, for example, the digital cloud-connected platform monitors performance in real-time to ensure the BESS delivers on contract specific KPI's. The platform will alert about any deviations, enabling immediate action. AI allows the implementation of predictive maintenance functionalities, further reducing downtime, cost and safety risks thanks to the detection and thorough interpretation of weak signals within a tremendous amount of data gathered and stored by the system.

It is also now possible to resolve most issues without ever needing a site visit, thanks to remote diagnostic and reconfiguration tools.

CONCLUSIONS

The tide is now turning. Most countries -and resulting energy policies- recognize the need to invest into both flexibilities and grid capacities, in order to integrate massive amounts of wind and solar energy so as to match their carbon reduction targets. BESS are not only efficient alternatives to fossil-based flexibilities, but they are also crucial enablers to capture, store and deploy that energy when it is needed. By doing so, they are instrumental to help balance demand and supply, to constitute precious capacity reserves and to prevent grid congestion and curtailment, in other terms avoid wasting energy – an increasingly precious resource in today's world.

With a track record of more than 7.5 GWh of BESS installed or under construction worldwide, Saft offers expertise in battery energy storage systems to developers from project inception to installation and end of life. Our brand stands for reliable, guaranteed high performance product solutions, excellence in project execution and reliable service over decades, thus securing return on investment for long-life battery assets.

HUAWEI

BALANCING THE GRID: PHOTOMATE AND HUAWEI EXPERIENCE, AND LESSONS FOR CENTRAL ASIA

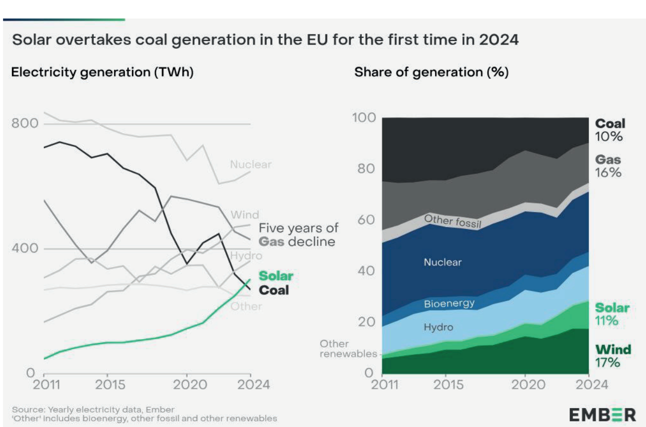
CHALLENGES FACING THE EUROPEAN POWER SYSTEM

THE GROWTH OF RENEWABLE ENERGY SOURCES IN EUROPE

Over the past decade, Europe has become a global leader in the adoption of renewable energy. Driven by ambitious climate goals, policy frameworks such as the European Green Deal, energy safety and significant public and private investment, the share of renewables in the energy mix has seen a substantial rise.

In 2023, the EU's renewable energy share in electricity consumption climbed to 45.3%, up from 41.2% in 2022, according to Eurostat. The main contributors were:

- Wind energy: 38.5% of total renewable electricity generation.
- Hydropower: 28.2%
- Solar PV: 18.6%
- Bioenergy and others: 14.7%



This trend continued in 2024, when solar energy surpassed coal for the first time in EU history, supplying 11% of the electricity compared to coal's 10%.

The EU aims to further increase this share to at least 63% by 2030, aligning with net-zero goals by 2050. National energy plans from Germany, France, Spain, and others contribute significantly to this momentum, with record additions expected in 2025: 70 GW of solar and 19 GW of wind installations projected.

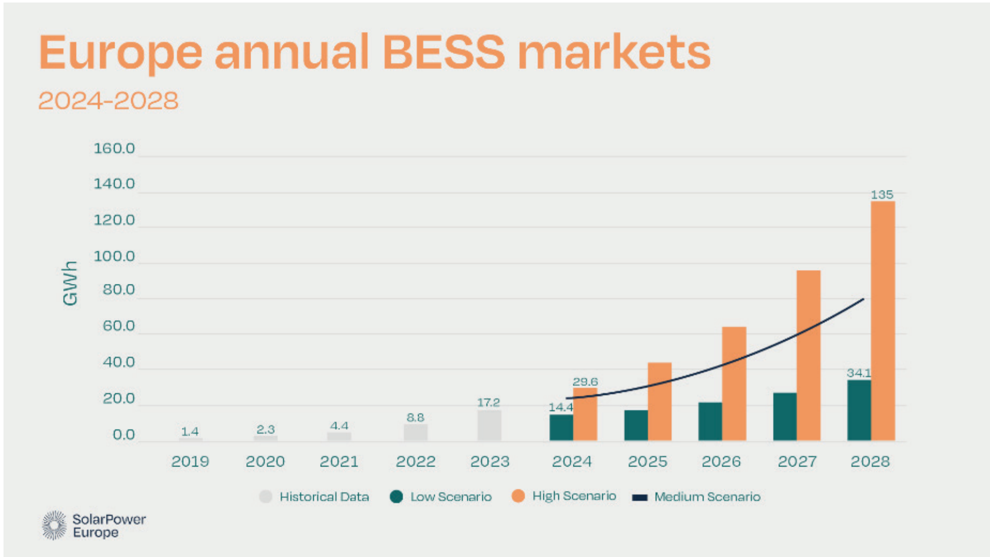
While the rapid growth of renewables mainly in PV and wind power is commendable, integrating them into traditional electricity grids has presented multi-dimensional challenges.

Intermittency and variability –renewables like wind and solar are non-dispatchable, their output depends on weather and time of day. This introduces uncertainty and volatility in energy supply, unlike fossil fuel-based plants which offer consistent output. This variability leads to frequent mismatches between generation and demand. This can affect grid stability in term to frequency instability or voltage fluctuations.

Grid congestion and curtailment - as renewable installations grow, especially in remote areas with high wind or solar potential, the existing transmission infrastructure becomes a bottleneck. Most renewable generation is built where natural resources are rich, for example wind farms in northern Germany or solar fields in southern Spain but demand is often concentrated in industrial or urban centers elsewhere. This mismatch stresses the transmission infrastructure, which lacks the capacity to move large volumes of power over long distances.

Battery energy storage systems as pillar of modern grid – are they essential?

All the aforementioned challenges, along with the decline in energy storage system prices driven by increased supply and supportive economic programs introduced by European governments, have contributed to a rapid growth in the share of battery energy storage systems since 2024. This has occurred alongside a planned (at minimum) doubling of their deployment.



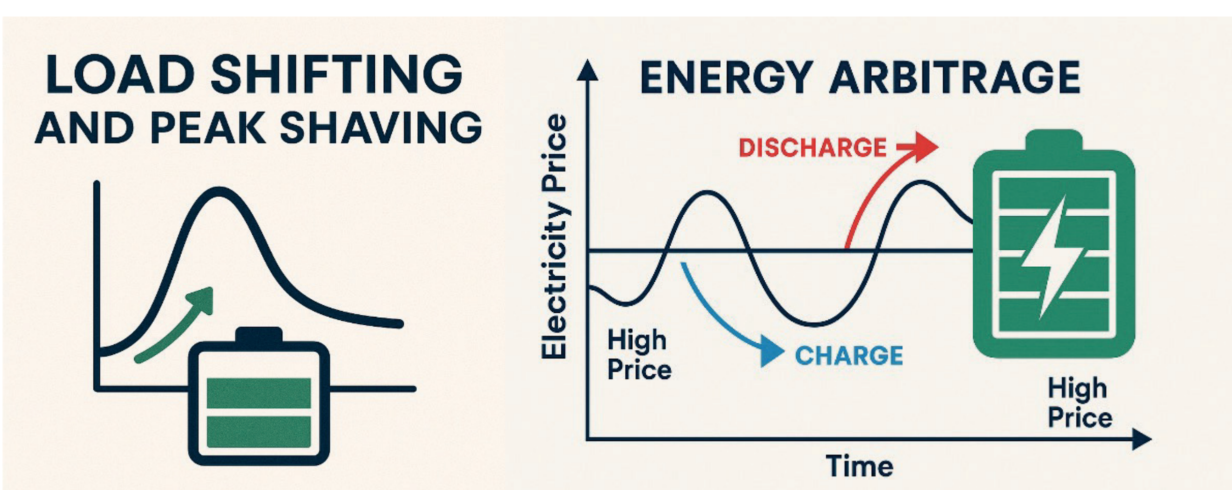
Battery energy storage systems currently represent one of the most advantageous solutions for addressing the tasks and challenges Europe faces in the context of energy transition. How can they contribute to this goal? These systems offer a wide range of advanced functionalities which, when integrated with digital technologies, form an essential component of sustainable development.

Key Functions of Battery Energy Storage Systems

BESS are versatile and can perform a range of functions, broadly categorized as follows:

Arbitrage in battery energy storage means buying electricity when it's cheap (usually during low demand) and selling it when prices peak. This helps BESS operators earn revenue by exploiting daily price fluctuations. A key benefit is reducing renewable energy curtailment—when excess solar or wind energy goes unused due to low demand or grid constraints. By storing surplus green energy and using it during high-demand periods, BESS supports cleaner energy use and boosts profits for developers. In systems without formal electricity markets, this strategy also aids load-leveling—balancing supply and demand by shifting energy use across time.

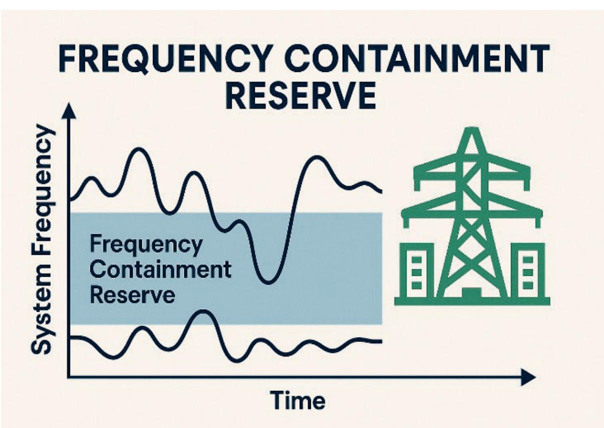
Firm Capacity or Peaking Capacity is the ability of the power system to meet electricity demand during the highest-use periods of the year. Traditionally, this role is filled by expensive, fast-ramping generators like gas plants. However, Battery Energy Storage Systems (BESS) can also serve as a reliable source of peaking capacity by storing energy during low-demand periods and discharging it when demand spikes.



Variable Renewable Energy (VRE) sources (like wind and solar) can contribute to firm capacity, but their output depends on weather and often doesn't align with peak demand. Because of this, their firm capacity value is limited. By pairing VRE with BESS, system operators can shift renewable generation to match peak load times more effectively. This integration not only improves system reliability but also enhances the capacity value of renewables, reducing reliance on fossil-fuel plants.

Operating Reserves and Ancillary Services are essential for keeping the power grid stable, ensuring supply matches demand in real time. These services operate on various timescales—from fractions of a second to several hours to respond to sudden changes in grid conditions.

Battery Energy Storage Systems (BESS) are ideal for these tasks because they can react almost instantly, much faster than traditional power plants. This makes them well-suited for fast-response services like Primary Frequency Response (PFR) and Regulation. Larger or longer-duration BESS setups can also support load-following and ramping, helping to balance supply and demand over longer periods. In this way, BESS plays a key role in grid reliability and flexibility.

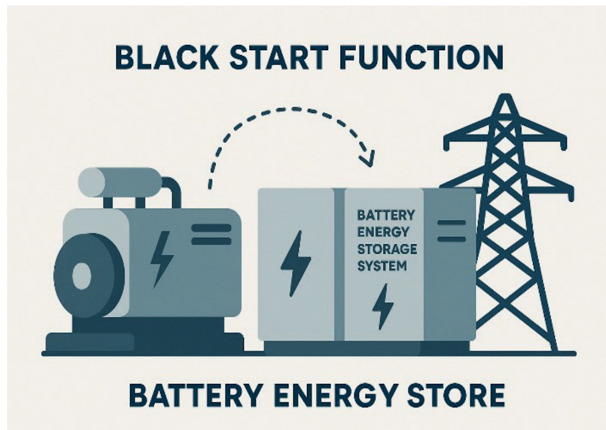


Black Start is the process of bringing power plants back online after a complete grid shutdown, when no external electricity is available. Normally, generators draw power from the grid to activate control systems and restart operations. But during a full outage, an independent source is needed.

Traditionally, this backup is provided by on-site diesel generators. However, Battery Energy Storage Systems (BESS) offer a cleaner and more efficient alternative. BESS can instantly supply the necessary startup power without fuel costs or emissions. Moreover, because large-scale outages are rare, a BESS installed for black start can also be used to deliver other valuable grid services such as frequency regulation or energy arbitrage, when it's not on standby. This makes it a versatile and cost-effective investment for system operators.

Powering Energy Storage Solutions from Europe to Central Asia

As the role of battery energy storage becomes increasingly central to the resilience and flexibility of Europe's power system, technology providers play a critical part in implementing these technologies effectively.

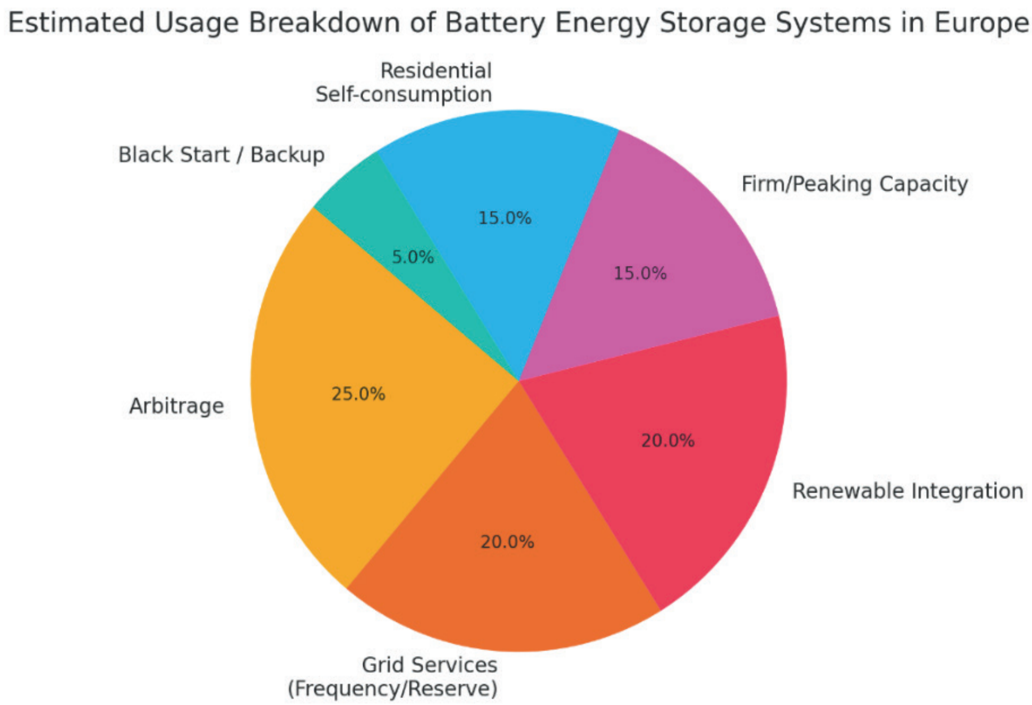


Photomate - a trusted provider of HUAWEI Battery Energy Storage Systems (BESS) combines European deployment expertise with a deep understanding of storage's critical role in modern energy grids. As a Huawei Value Added Partner, we also deliver cutting-edge solar technologies including FusionSolar inverters, Smart Transformer Stations, EV chargers, and energy management solutions for residential, commercial, and utility-scale applications. Our comprehensive portfolio is supported by advanced consumption analysis services.

Backed by a technical team of 60+ skilled engineers, each contributing specialized regional knowledge, we deliver tailored energy solutions that meet the unique demands of diverse markets. We spoke with our colleagues to highlight standout BESS projects across Europe, explore current market trends, and identify the most common application scenarios for energy storage.

ENERGY STORAGE MARKET DEVELOPMENT IN HUNGARY

Hungary's energy landscape is undergoing significant transformation as solar PV capacity continues its rapid expansion, now reaching levels that require additional system support. With renewable penetration increasing, the country has introduced substantial support mechanisms, including the RRF-6.5.1-23 subsidy scheme allocating €150 million for utility-scale energy storage projects. These subsidized projects combine CAPEX/OPEX support with



ancillary service obligations, creating favorable conditions for development. Beyond subsidized projects, the Hungarian electricity and ancillary markets already offer viable economics for energy storage systems, with commercial and industrial sector projects demonstrating 3–5-year payback periods. The 6.5.1-23 program has catalyzed development of approximately 440MW of 2-hour storage capacity, with majority expected operational by April 2026.

Application Scenarios and Project Spotlight

Utility-scale storage predominantly supports automated Frequency Restoration Reserve (FRR) and daily arbitrage operations, while C&I installations typically address zero-feed-in limitations by storing PV overproduction for later use.

SHOWCASE: 9MW/18MWh Alteo Győr project

Last year, our team successfully delivered and commissioned a Battery Energy Storage System for Alteo Group—a Hungarian energy service and trading company. The project, located in Győr, Hungary, contributes directly to Alteo's expanding virtual power plant (VPP) portfolio.

Project Overview

The Alteo Győr BESS project features a 9 MW / 18 MWh storage system produced by Huawei. The system is engineered to deliver frequency containment (FCR), automatic frequency restoration reserve (aFRR), and energy arbitrage, forming a critical part of Alteo's dispatchable portfolio.

Main components of the installation include:

- 1 x STS-3000K-H1 & 1x STS-6000K-H1 smart transformer stations
- 9 x Luna2000-2.0MWh-2H1 Battery units
- 45 x Luna2000-200KTL-H0 Smart PCS

Integration and Implementation

The BESS was deployed alongside existing gas engine infrastructure and connected to a medium-voltage line shared with wind turbines.

The Huawei system's high-precision control and rapid response time were crucial for meeting the stringent requirements of FCR (Frequency Containment Reserve) accreditation. From a certification standpoint, Huawei's technology complies with all necessary regulatory and grid code standards, ensuring seamless integration into ancillary service markets.

Despite its size, the installation process was smooth and well-coordinated - this seamless integration showcases Photomate team's capability to manage multi-technology environments, ensuring reliability and compliance with grid codes and safety standards.

ENERGY STORAGE MARKET DEVELOPMENT IN SWEDEN

Östersund Project

As Sweden together with other European countries faces growing electricity price volatility and grid imbalances, driven by increased renewable energy and rising demand in the south, BESS have become a key part of the solution. With no direct subsidies available for utility-scale BESS, the market is still booming thanks to strong business cases driven by

Photomate, Alteo Project, Győr, Hungary

frequency regulation, price arbitrage, and peak shaving.

One of Photomate's standout projects, realized in the country, is the Östersund-BESS tvätthallen, commissioned in 2024 by Energi & Driftteknik AB, a leading Swedish energy infrastructure developer. Located in Östersund, the 4MW/4MWh system supports a virtual power plant (VPP), delivering services such as FCR, aFRR, and energy arbitrage.

The solution includes:

- 1x STS-6000K-H1 smart transformer station
- 2x LUNA2000-2.0MWH-1H1 battery units

Despite harsh winter conditions with temperatures below -30°C, the Huawei BESS has delivered reliable and efficient performance, maintaining strong power output and quality.

Energi & Driftteknik partnered with Photomate for end-to-end support—from system design to installation and performance verification. The project faced several challenges, including:

- A limited 3MW grid connection, which will be expanded in the future
- Installation in extreme cold, requiring detailed planning and supervision
- Compliance with Swedish MV connection standards (IBH21), solved by building a cost-effective intermediary station

The customer chose Huawei BESS for its proven reliability, efficiency, and competitive cost, along with strong local service and support.

HUAWEI BESS IN THE RED SEA PROJECT: POWERING SAUDI ARABIA'S SUSTAINABLE VISION

As energy transition efforts expand beyond Europe, Huawei's Battery Energy Storage Systems (BESS) are also being deployed in landmark international initiatives. A notable example is the Red Sea Project in Saudi Arabia—one of the world's most ambitious sustainable tourism and infrastructure developments. Designed to run entirely on renewable energy, this off-grid mega project relies on advanced storage technologies to guarantee 24/7 clean power supply across hundreds of islands, resorts, and infrastructure nodes.

The Red Sea Project's integrated energy system includes more than 760,000 solar panels and a large-scale utility battery storage system with a total capacity of 1.3 GWh—the largest off-grid BESS installation globally at the time of commissioning.

Photomate, Energi & Driftteknik AB Project, Östersund, Sweden

Project Overview

Huawei played a direct and critical role in delivering smart energy storage technologies and worked closely with the system integrator SEPCOIII to design and implement the massive energy system. The BESS solution ensures uninterrupted, emission-free power throughout day and night, supporting everything from desalination plants and hotels to airport and transportation services.

Key project highlights include:

• Deployment of LUNA2000 series battery containers across multiple distributed nodes

• Integration with Huawei's smart Power Conversion System (PCS) for seamless control and high-efficiency conversion

• Full compatibility with the Red Sea's hybrid renewable infrastructure—including solar PV, smart grids, and microgrid control systems

Huawei is particularly proud of its contribution to this flagship project, which represents a milestone for large-scale off-grid energy storage and showcases the company's leading role in enabling clean, reliable power for complex infrastructure developments.

Huawei, Red Sea Project, Saudi Arabia

ADDRESSING THE FLEXIBILITY GAP: BESS AS A STRATEGIC SOLUTION FOR KAZAKHSTAN

One of the most pressing challenges in Kazakhstan's power sector today is the shortage of flexible, or "regulating," capacity—a situation that becomes increasingly critical as the share of renewable energy grows. According to Kazakhstan's national grid operator, KEGOC, the situation in Kazakhstan's Unified Power System is becoming increasingly challenging due to the expected integration of 16 GW of renewable energy capacity in the coming years. This includes 3.3 GW under existing contracts, 6.7 GW planned through auction tenders for 2023-2027, and 6 GW from major projects with foreign investors.

The approved Forecast Balance of Electricity and Capacity for 2023-2029 projects a shortage of regulating capacity reaching 1,364 MW by 2025. Currently, the power system already operates under monthly deficit conditions, necessitating the implementation of consumer restrictions, that makes balancing and grid stability more urgent than ever.

Many of Kazakhstan's thermal power plants, particularly older coal-fired, lack the flexibility to ramp up or down quickly. According to KEGOC, the country is experiencing a deficit of maneuverable capacity, especially in the southern regions and during peak hours, such as mornings and evenings.

The variable nature of solar and wind power, which depend heavily on weather conditions, presents additional challenges. These sources often generate electricity in unpredictable patterns, creating sharp fluctuations in supply that Kazakhstan's current energy infrastructure struggles to manage effectively.

Recognizing this, KEGOC and the Ministry of Energy are actively exploring BESS as a core solution. Battery Energy Storage Systems can store excess renewable power during periods of high generation—such as sunny afternoons or windy nights—and release it during peak demand, helping to smooth out imbalances and strengthen the grid.

Complementary Measures and Smart Grid Integration

In addition to BESS, Kazakhstan is also considering the development of gas-fired power plants and hydropower, both of which offer high flexibility and can play a valuable role in balancing variable renewable generation.

KEGOC is rolling out SCADA/EMS digital control systems and plans to implement predictive algorithms to better forecast renewable output and manage energy flows in real time. These upgrades are part of a broader move toward smart grid infrastructure, which will be essential as the share of renewables increases.

Risks of Inaction

Without sufficient regulating capacity, Kazakhstan risks facing a range of system-level issues, including:

Many of Kazakhstan's thermal power plants, particularly older coal-fired, lack the flexibility to ramp up or down quickly. According to KEGOC, the country is experiencing a deficit of maneuverable capacity, especially in the southern regions and during peak hours, such as mornings and evenings.

• Load shedding or consumer outages, including for industrial users, due to instability in supply-demand balance

• Increased dependence on electricity imports from Russia, Kyrgyzstan, and Uzbekistan during peak stress periods

• Barriers to further renewable energy deployment, as the system may not be able to accommodate additional variable capacity without stability concerns

National Vision: Flexibility as a Cornerstone of Energy Transition

As Kazakhstan prepares for a major shift toward renewable energy, flexibility is emerging as a critical requirement—and Battery Energy Storage Systems (BESS) are increasingly viewed as a key enabler for stabilizing the grid and supporting future deployment.

KEGOC, Kazakhstan's national grid operator, is taking the lead in setting clear technical and operational rules for new renewable energy projects. These rules are designed to make sure that clean energy projects also support the reliability and safety of the overall electricity system.

Both KEGOC and the government acknowledge that without new flexible resources and energy storage, the growth of renewables may become a limiting factor for system reliability. In its recent reports from 2023–2024, KEGOC emphasized that storage and flexible generation must be prioritized to enable sustainable renewable integration.

At the same time, the Ministry of Energy is introducing regulatory reforms that require energy storage for large-scale renewable projects (10 MW and above), aligning policy with the technical needs of the grid.

Kazakhstan's energy strategy through 2035 sets a clear path forward, focused on grid infrastructure modernization, a transition to smart systems, and the implementation of pilot BESS projects. These steps will form the foundation of a more adaptive, secure, and clean energy future.

Empowering the Net-Zero Era: Envision Energy's Smart Storage Revolution

IN A WORLD WHERE ENERGY TRANSFORMATION IS NO LONGER A GOAL BUT A NECESSITY, ENVISION ENERGY STANDS AT THE FOREFRONT—EMPOWERING INDUSTRIES AND COMMUNITIES WITH INTELLIGENT, SCALABLE, AND SUSTAINABLE SOLUTIONS. WITH A GLOBAL PRESENCE AND A COMMITMENT TO TECHNOLOGICAL EXCELLENCE, ENVISION IS NOT ONLY ACCELERATING THE CLEAN ENERGY TRANSITION BUT ALSO RESHAPING THE FUTURE OF POWER SYSTEMS.

Envision | Net Zero Tech Partner

ENVISION ENERGY: A GLOBAL GREEN TECH POWERHOUSE

Envision Energy is a world-leading green-tech company committed to becoming a net zero technology partner for global enterprises, governments, and institutions.

Encompassing three major business sectors - Smart Wind Turbines, Energy Storage, and Green Hydrogen Solutions, Envision Energy constructs comprehensive solutions for energy transition.

With over 20 global R&D centers, 50+ manufacturing bases, and operations spanning more than 15 countries, Envision is recognized as a true innovator. In 2024, it earned a place on TIME's "100 Most Influential Companies" list and Fortune's "Change the World" ranking for its breakthrough work in net-zero industrial parks and green hydrogen. Envision also achieved global operational carbon neutrality in 2022 and is ambitiously targeting full net-zero status by 2040.

With over 20 global R&D centers, 50+ manufacturing bases, and operations spanning more than 15 countries, Envision is recognized as a true innovator.

SMART, SUSTAINABLE STORAGE: ENVISION ESS OVERVIEW

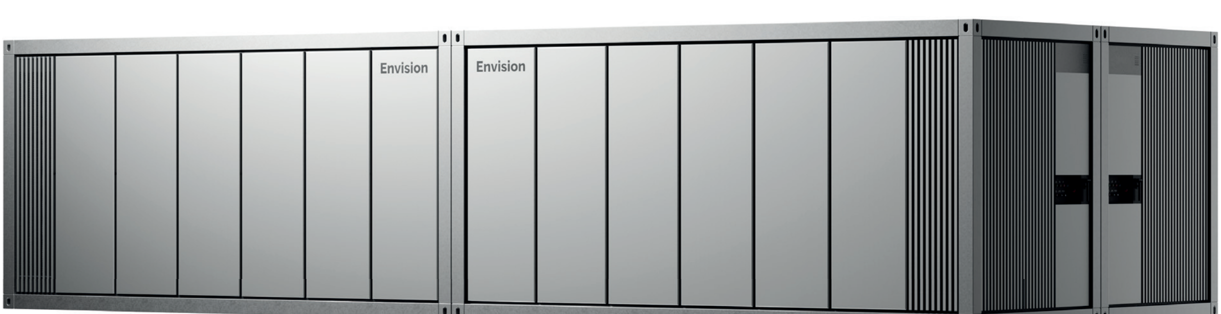
At the core of Envision's green mission lies its Energy Storage Systems (ESS)—a vital enabler of renewable integration and grid flexibility. With over 30 GWh shipments and more than 50 GWh in orders, Envision ESS is rapidly scaling to meet the world's growing need for safe, reliable, and intelligent energy storage.

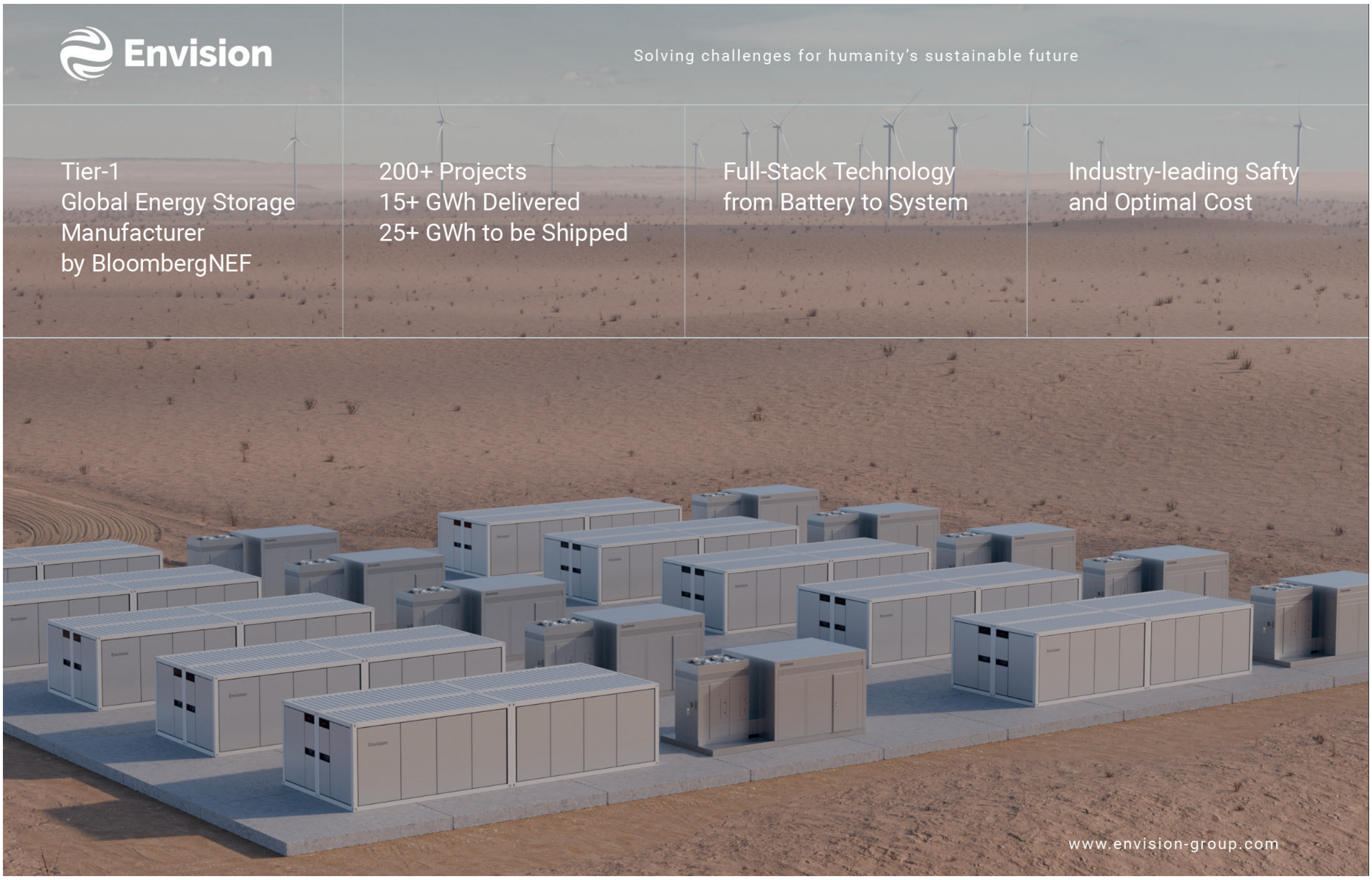
Backed by in-house R&D and vertically integrated manufacturing—from battery and packs to PCS, BMS, EMS, and SCADA systems—Envision ensures total quality control and operational excellence across the value chain. Its AI- and IoT-powered platform offers real-time monitoring, predictive analytics, and seamless smart grid integration.

TECHNOLOGICAL EXCELLENCE: BUILT FOR SAFETY, RELIABILITY & PERFORMANCE

Envision ESS is engineered for maximum safety, efficiency, and long-term durability, with a particular emphasis on degradation modeling, AI-optimized asset management, and grid-forming capabilities. Its innovative product suite includes both DC and AC solutions:

- DC Cabinet Solutions use advanced LFP 280 Ah and 305 Ah cells for extended lifecycle and system flexibility. Their pre-installed design reduces onsite work and BOP costs.
- 5MWh Liquid-Cooled DC Containers feature high-capacity 315 Ah cells, enhanced thermal management, and robust safety features—ideal for harsh environments, low-noise zones, and frequency support applications.
- AC Power Conversion Systems (PCS), such as the





SingleSkid3300, TwinSkid5500, and TwinSkid6900, deliver over 98.5% efficiency, high reliability, and grid-forming stability, particularly in weak or remote grids.

Through its proprietary battery management systems and predictive degradation data analysis, Envision enables smarter, longer-lasting, and safer operation—ensuring maximum ROI and uptime for operators.

REAL-WORLD IMPACT: GLOBAL PROJECTS DRIVING CHANGE

Envision's storage solutions are set to power some of the world's most impactful energy projects, underscoring its global expertise and local execution:

- Harmony Energy Income Trust (UK) – 83MW/166MWh BESS stabilizing grid and renewables integration.
- Masdar Arlington Energy (UK) – 55MW/110MWh serving the UK's flexible energy market.
- EDF Oasis Project (South Africa) – 257MW/1028MWh, one of Africa's largest battery deployments.
- Juniper Green Energy (India) – 320MWh capacity supporting peak load demands and renewables.
- Scatec Mogobe (South Africa) – 103MW/493MWh system boosting local energy independence.
- Atlantic Green, Cellarhead (UK) – 300MW/624MWh for resilience and frequency response.
- Field Energy, Whitebirk (UK) – 25MW/50MWh site stabilizing regional networks.

Each deployment showcases Envision's unique blend of technical excellence, adaptability, and global project delivery capabilities, all aligned with its commitment to accelerate a sustainable energy future.

A SMARTER, GREENER FUTURE

From hardware innovation to digital intelligence, Envision Energy Storage is redefining what's possible in the battery storage industry. Its integrated solutions are not just responding to today's challenges—they are proactively shaping tomorrow's energy systems.

As the world moves toward decarbonization, Envision Energy stands ready—with the technology, scale, and vision to power the transition to a net-zero future.

Envision Energy Storage: Born for the renewable system. Designed to power the future.

For more information please visit:www.envision-group.com. Country representative: Almas Bek almas.bek@envision-energy.com

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		50	The Southern Zone	May 26, 2025
2	WPP		100	The Northern Zone	May 27, 2025
3	WPP		50	The Western Zone	May 28, 2025
4	WPP		1000*	The Northern Zone	May 29, 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. 66- N/K dated February 7, 2025. "On approval of the auction schedule until 2025"

**With an electric power storage system*

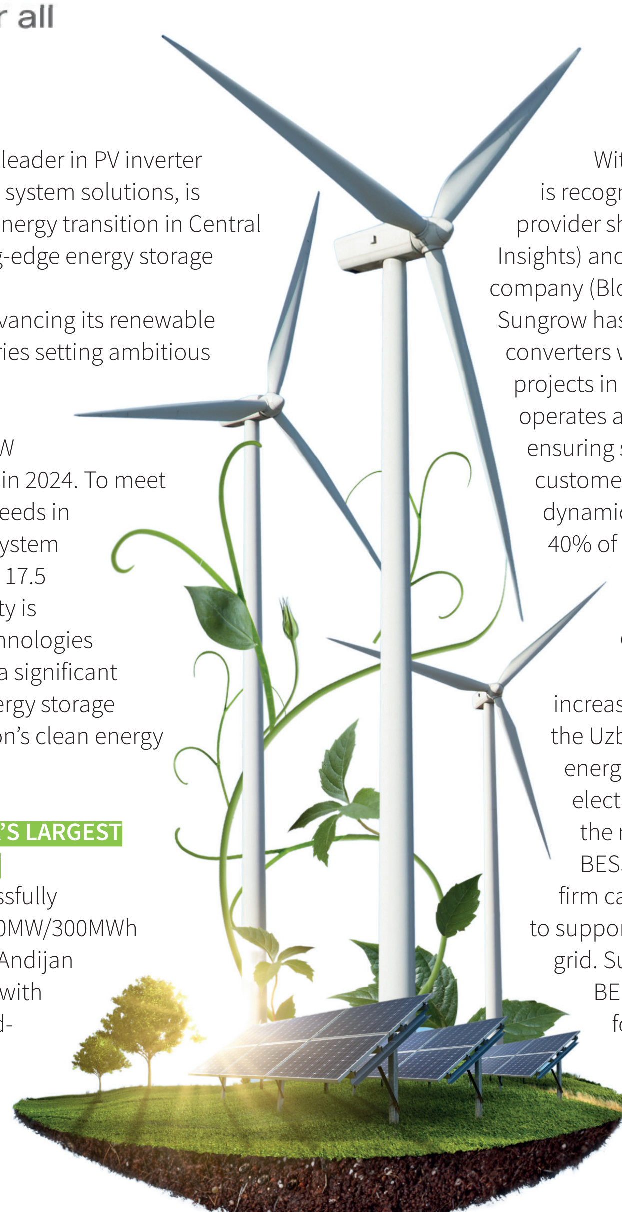
The total auctioned installed capacity in 2025 is 1,810 MW, broken down by type of power plants:

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

SUNGROW LEADS CENTRAL ASIA'S LARGEST ENERGY STORAGE PROJECT

SUNGROW PIONEERS CENTRAL ASIA'S LARGEST ENERGY STORAGE PROJECT AND ADVANCES CLEAN ENERGY TRANSITION WITH CUTTING-EDGE BESS SOLUTIONS

SUNGROW
Clean power for all



Sungrow, the global leader in PV inverter and energy storage system solutions, is spearheading the energy transition in Central Asia with its cutting-edge energy storage system.

Central Asia is steadily advancing its renewable energy transition, with countries setting ambitious targets for clean power integration. Kazakhstan has already commissioned 3.03GW of renewable energy projects in 2024. To meet future energy consumption needs in Kazakhstan's Unified Power System (UPS) by 2035, approximately 17.5 GW of new generation capacity is planned, utilizing various technologies and locations. This presents a significant opportunity for advanced energy storage solutions to support the region's clean energy transition.

CASE STUDY: CENTRAL ASIA'S LARGEST ENERGY STORAGE PROJECT

Recently, Sungrow has successfully commissioned the Lochin 150MW/300MWh energy storage project in the Andijan Region, Uzbekistan. Installed with Sungrow's cutting-edge liquid-cooled BESS PowerTitan 2.0, this facility marks Uzbekistan's first energy storage project and is the largest in Central Asia.

With over 28 years of experience, Sungrow is recognized as the world's No. 1 PV inverter provider shipment (S&P Global Commodity Insights) and the most bankable energy storage company (BloombergNEF). As of December 2024, Sungrow has deployed 740GW of power electronic converters worldwide, supporting clean energy projects in over 180 countries. The company operates a 520-outlet global service network, ensuring seamless project execution and customer support. Sungrow possesses a dynamic technical R&D team that represents 40% of the company's personnel. The Company has also invested in its in-house testing center approved by SGS, CSA, and TÜV Rheinland.

Uzbekistan is planning a rapid increase in renewable actions. In early 2024, the Uzbek government raised its renewable energy target from 25% to 40% of the electricity mix by 2030. As a vital part of the national plan, the Lochin 300MWh BESS project will provide 2,190GWh of firm capacity and flexible power annually to support a more resilient local electricity grid. Sungrow supplied its PowerTitan 2.0 BESS which is embedded with the gird-forming technology, delivering voltage regulation, frequency response, and oscillation damping services, ensuring a stable voltage and frequency in the weak Uzbekistan grid.

The Lochin 150MW/300MWh energy storage project

STORAGE WITH LIQUID-COOLED POWERTITAN 2.0

Sungrow's Liquid-Cooled PowerTitan 2.0 Energy Storage System is designed to support central Asia's clean energy transition with its advanced features:

- PowerTitan 2.0 is a professional integration of Sungrow's power electronics, electrochemistry, and power grid support technologies. The all-in-one AC-DC block design, with pre-assembled battery modules and PCS, ensures seamless integration and ease of installation, streamlining the grid connection time by 50%.
- It offers a highly scalable design with plug-and-play architecture, supported by pre-certified fire safety compliance testing. Sungrow also conducted the world's largest BESS burn test for PowerTitan 2.0 last October, setting new safety standards.
- It integrates iSolarBPS, pioneering battery pre-diagnostics with real-time monitoring and three-tier warning capabilities.

For commercial and industrial (C&I) applications, Sungrow also offers PowerStack 200CS, a 110kW/225kWh energy storage system featuring automated grid switching, integrated battery and PCS management, and liquid-cooling for superior heat dissipation.

EXPANDING BESS DEPLOYMENT ACROSS CENTRAL ASIA

As Kazakhstan continues its ambitious renewable energy expansion, Sungrow remains committed to supporting the region's clean energy transition with tailored BESS solutions that enhance grid stability and renewable energy integration. Beyond Kazakhstan, Sungrow is strengthening its presence in Central Asia, working closely with partners to provide reliable and scalable energy storage solutions that drive the region's sustainable energy future.

ENERGY STORAGE SYSTEMS: REGULATION AND INCENTIVES IN KAZAKHSTAN

KAZAKHSTAN IS WITNESSING ACCELERATED GROWTH IN RENEWABLE ENERGY SOURCES (RES) AS PART OF ITS EFFORTS TO ACHIEVE CARBON NEUTRALITY AND DIVERSIFY ITS ENERGY PORTFOLIO. IN 2024, THE SHARE OF RES IN KAZAKHSTAN ACCOUNTED FOR 6.4% (7.58 BILLION KWH) OF TOTAL ELECTRICITY GENERATION. IN 2025, THE COUNTRY PLANS TO COMMISSION 9 RENEWABLE ENERGY PROJECTS WITH A TOTAL CAPACITY OF 455.5 MW.

unicase

Raushana Chaltabayeva, Partner at Unicase

Kurmet Zhumagaliyev, Senior Associate at Unicase

A major barrier to the efficient and economical integration of renewables into the unified energy system is the intermittency of solar and wind power, as these sources are not available around the clock.

The most widely recognized solution to this issue is the implementation of energy storage systems (hereinafter – ESS), which are designed to accumulate electricity and release it during peak demand periods. As global practice shows, energy storage systems (ESS) are successfully used in various applications, including grid stabilization and frequency regulation, peak shaving and load shifting, integration of renewable energy sources, backup power and resilience, support for microgrids, and integration into electric vehicle charging infrastructure. Currently, lithium-ion batteries are the most popular choice for battery-based energy storage systems. They are characterized by high energy density, long service life, and fast charging capability, and are used in residential, commercial, and grid-scale storage applications.

The growth rates of ESS exceeded all expectations in 2024, with ESS installations totaling 205 GWh globally. According to BloombergNEF's forecasts, the global market for battery energy storage systems (BESS) will grow by 21% annually until 2030, highlighting the increasing demand and commercial viability.

A pilot project for the implementation of ESS is planned based on the signed agreement between KEGOC JSC, China Power International Development Limited, China Power International Holding Limited, and the Union of Legal Entities "Association of Renewable Energy of Kazakhstan". This pilot project will allow for the study of the practical characteristics and potential of using ESS within the unified power grid.

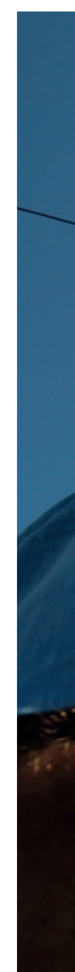
Additionally, the construction of wind and solar power plants is expected based on intergovernmental agreements, which outline the terms for the implementation, development, construction, and operation of power plants, utilizing an energy storage system with a minimum capacity.

CURRENT REGULATORY FRAMEWORK

According to the Concept of Development of the Fuel and Energy Complex of the Republic of Kazakhstan for 2023-2029 (hereinafter referred to as the Concept), it is planned to reduce the negative impact of growing renewable energy capacities on the country's power grid by introducing energy storage capacities totaling 11.7 gigawatts by 2029.

The Concept also outlines an Action Plan for its realization, which includes a provision for the implementation of renewable energy projects with a total capacity of 4000 megawatts, including ESS.

As of today, the main regulatory acts that currently govern, to varying extents, the relations related to the



installation and operation of ESS in the renewable energy sector are as follows:

- The Law of the Republic of Kazakhstan "On Supporting the Use of Renewable Energy Sources" dated July 4, 2009, No. 165-IV (hereinafter referred to as the "Renewable Energy Law");
- The Order of the Minister of Energy of the Republic of Kazakhstan dated December 18, 2014, No. 210 "On Approving the Electric Grid Rules" (hereinafter referred to as the "Electric Grid Rules"); and
- The Order of the Minister of Energy of the Republic of Kazakhstan dated March 30, 2015, No. 247 "On Approving the Rules for the Technical Operation of Electric Stations and Networks" (hereinafter referred to as the "Technical Operation Rules").

Definition of ESS

The Renewable Energy Law defines ESS as "a technical device with an automated control system designed for the accumulation, storage, and discharge of electrical energy, along with the associated structures and infrastructure required for its operation in accordance with the legislation of the Republic of Kazakhstan".

The Renewable Energy Law also includes ESS in the definition of auction trading, meaning that in certain cases, the selection of projects for the construction of new renewable energy facilities will be carried out with consideration of equipping such facilities with ESS. The definition of "auction trading" does not imply that all renewable energy projects participating in auction trading must be equipped with ESS. It should be noted that the Renewable Energy Law does not include a mandatory requirement for equipping renewable energy facilities with energy storage systems—whether these are renewable energy projects based on auction trading or other renewable energy facilities.

Operation and Management of ESS

Amendments and additions made to the Electric Grid Rules and the Rules for the Technical Operation regulate the technical aspects of ESS operation, including: the formation of the conceptual framework for ESS, the tasks and requirements for comprehensive testing of ESS, the requirements for ESS management through automated control systems, maintaining a certain charge level to prevent a decrease in ESS technical characteristics,

requirements for ESS accessibility, ESS requirements for frequency regulation and power flows, and others.

The Electric Grid Rules were also amended with provisions stipulating that, at the stage of developing and agreeing on the Power Output Scheme of a power plant, the selection of the following types of ESS is determined:

- Mechanical;
- Electrochemical;
- Chemical;
- Electric;
- Thermal.

When developing the Power Output Scheme, the project developer must adhere to the requirements of the Rules for the Technical Operation of Electric Stations and Networks, which define the procedures for the technical operation of power plants and networks, including renewable energy plants.

Expected developments in ESS regulation

As outlined in the draft Law of the Republic of Kazakhstan "On Amendments and Additions to Certain Legislative Acts of the Republic of Kazakhstan Regarding the Development of Alternative Energy Sources" (hereinafter referred to as the "Draft Law"), amendments and additions are expected to be made to various regulatory legal acts with the goal of enhancing the legal framework governing ESS.

Functioning of ESS in the Power System

The Draft Law introduces the concept of an energy storage system operator to clearly define a specialized market participant responsible for the management, operation, and integration of storage facilities into the energy distribution system.

The concept of the electric capacity market is being expanded to include a new participant—ESS operators—who are in a state of readiness to store and discharge electrical energy. This inclusion is intended to ensure the return on investments made in the ESS sector. Furthermore, under the proposed amendments, the ESS operator provides a service to the single buyer for the availability of energy storage system capacity, thereby ensuring the system's readiness to deliver load.

In addition, according to the Draft Law, participants involved in the generation, storage, transmission, and consumption of electricity will bear mutual obligations for financial settlement in the balancing electricity market. These obligations will be based on the differences between contracted and actual volumes of electricity generation and consumption, as determined by the system operator through calculations of balancing electricity volumes resulting from the physical settlement of energy imbalances. Thus, ESS will be integrated into the balancing electricity market.

Types of ESS

The terminology section of the Renewable Energy Law will be supplemented with the following types of ESS, which are expected to reduce grid load, promote the expansion of distributed generation, and ensure stable energy supply for various categories of consumers:

- Household energy storage system – an energy storage system intended for domestic use;
- Battery energy storage system – an energy storage system based on rechargeable batteries.
- Behind-the-meter energy storage system – an energy storage system installed in residential, commercial, or industrial facilities, located beyond the point of interconnection (behind the electricity metering device) on the consumer side, and designed to fully or partially meet the facility's own electricity demand through the accumulation, storage, and discharge of electrical energy.

SUPPORT MEASURES

Guaranteed Offtake

The amendments provide for the guaranteed purchase by the single buyer of the service for the availability of energy storage system capacity. This measure will enable the integration of ESS into the electric capacity market and ensure long-term financial support. It is proposed that the tariff for the service of energy storage system capacity availability be approved for a period of 15 (fifteen) years. The maximum tariff (price) for this service will include the recovery of capital expenditures and interest on relevant loans obtained for the project implementation, a rate of return on invested capital (subject to annual indexation), adjusted either by the inflation rate as determined by the authorized body in the field of state statistics, or by annual indexation based on changes in the exchange rate of the national currency to foreign currencies as determined by the National Bank of the Republic of Kazakhstan, as well as operational expenses.

This inclusion is intended to ensure the return on investments made in the ESS sector. Furthermore, under the proposed amendments, the ESS operator provides a service to the single buyer for the availability of energy storage system capacity, thereby ensuring the system's readiness to deliver load.

Access to Power Grids

According to the Draft Law, transmission companies will not have the right to deny ESS entities access to the electrical grid for the purposes of energy storage and subsequent discharge. Thus, non-discriminatory and transparent access of ESS to the power grid will be ensured.

Cap Tariff for Balancing Electricity

Entities using ESS, operating under the automatic frequency and power flow regulation system, will be granted the same rights to sell all their negative imbalances to the balancing market settlement center at the cap tariff for balancing energy, the value of which will remain unchanged for 5 years starting from March 1, 2025. Thus, the establishment of a non-decreasing cap tariff for balancing electricity will ensure the return on investment.

The Draft Law stipulates that all positive imbalances caused by the automatic frequency and power flow regulation system will be covered by entities using ESS through the purchase of balancing electricity from the balancing market settlement center at a price of 0.01 tenge/kWh, the same price applicable to other participants in the balancing electricity market.

ESS Auctions

The Draft Law proposes the introduction of a competitive selection mechanism for ESS investors through the organization and holding of auction tenders.

The Draft Law provides for the determination by the authorized body of the volumes of regulating electricity capacity that have been or will be created by energy storage system operators, as part of the plan for the placement of generating units with flexible generation modes. To implement this plan, auction tenders will be organized.

Auction tenders for selecting ESS projects will be organized and conducted by the auction organizer in an electronic system, based on an auction aimed at selecting ESS projects and determining their individual tariffs for the service of energy storage system capacity availability.

The process of organizing and conducting auction tenders for the selection of ESS projects will follow this procedure:

1. Defining the cap tariff for the service of ESS capacity availability.
2. Submission by the applicant of copies of the founding documents and proof of financial resources.
3. The commission, formed by the authorized body, will verify the documents submitted by the applicant for compliance with the requirements for ESS auction tenders and make a decision regarding the subsequent admission for registration in the electronic system of the auction organizer.
4. After the commission verifies the documents, the authorized body will send the information and the list of applicants who have been granted registration approval to the auction organizer.
5. No later than six months before the planned date of the auction tender, the authorized body will develop and publish on its website a schedule for holding auction tenders for the selection of energy storage system projects.

After the results are concluded, the single purchaser will sign a contract for the purchase of the energy storage system capacity availability service with the auction winner for a term of ten years from the date of its first certification, at the individual tariff for the energy storage system capacity availability service, determined based on the results of the auction tender for the selection of ESS projects.

Regulation within the framework of intergovernmental agreements

To implement the Action Plan for the deployment of ESS within the framework of the Concept, the construction of large-scale renewable energy projects based on intergovernmental agreements (hereinafter - IGAs) is planned. For example, the installation of ESS is provided for by the following IGAs:

• the Agreement between the Government of the Republic of Kazakhstan and the Government of the United Arab Emirates on the implementation of a wind power plant project;

• The Agreement between the Government of the Republic of Kazakhstan and the Government of the Kingdom of Saudi Arabia on the implementation of a wind power plant project.

• The Special Agreement between the Government of the Republic of Kazakhstan and the Government of the French Republic on the implementation of cooperation in the field of combating global warming.

The above-mentioned intergovernmental agreements also define indicative prices for the sale of electricity, taking into account ESS. At the same time, the principle for calculating the tariff (price) for ESS is determined based on different approaches.

According to the IGA with the Government of the French Republic, the sale of electricity will be carried out at an indicative price, which includes the tariff for ESS. A similar approach is outlined in the IGA with the Government of the United Arab Emirates, where a unified tariff is defined for each project. Thus, in these IGAs, the ESS tariff is included in the overall electricity sale price.

In the IGA with the Government of the Kingdom of Saudi Arabia, however, a different approach is outlined, where the single buyer will make separate payments to the seller for electricity and for ESS.

Considering the provisions of the Law on "Legal Acts," all such provisions in the IGAs regarding the possibility of concluding a power purchase agreement by the single

buyer outside of an auction, tariff models for electricity and ESS, which help compensate for ESS costs, take precedence over the existing national legislation of the Republic of Kazakhstan.

RECOMMENDATIONS

Investment preferences

Currently, ESS are not listed among the priority activities for the implementation of investment projects approved by the Government of the Republic of Kazakhstan. The inclusion of Energy Storage Systems (ESS) in this list would make the ESS sector more attractive to investors by offering various forms of support, such as exemption from customs duties, state grants in kind, and tax preferences, including reductions in corporate income tax, land tax, and property tax.

Increase in Local Content

It is recommended to set tariffs on fully imported lithium-ion battery modules, cells, racks, and semi-assembled BESS blocks in order to stimulate local assembly and job creation. Higher tariffs on fully assembled BESS products will enhance the competitiveness of local assembly and manufacturing.

PPP

The use of public-private partnership (PPP) potential is seen as one of the ways to achieve public benefit for

the public partner by gaining international experience in financing, developing, and managing/operating BESS projects from the private partner, while a more balanced risk allocation between the partners will positively affect the interests of both sides.

In the World Bank's Guidelines to Implement Battery Energy Storage Systems under PPP frameworks, four types of agreements are considered:

• A tolling agreement, in which the buyer pays a fee for access to the capacity provided by the ESS project and is also responsible for supplying and paying for the energy used to charge the ESS.

• A capacity agreement, in which the buyer pays for capacity or availability. The agreement will specify what the purchase of capacity entitles the buyer to, i.e., whether it is limited to the provision of certain services.

• The "capacity plus energy" agreement, where the buyer pays both for the capacity and for the energy. This may be appropriate if the project is responsible for paying for the energy used to charge the battery. In this case, the energy losses on the way to and from the battery essentially become variable costs, which are passed on to the off-taker through the energy charge;

• the Hybrid PPA, which is an extended PPA for renewable energy projects, for implementing a hybrid project that combines a VRE generator with a BESS installation. The PPA of this kind may compensate for energy production based on measured output (similar to a standard VRE project), while also setting conditions for the project, such as restrictions on growth rates or limited dispatchable capacity during specific timeframes.

For the successful implementation of PPP projects in the energy storage sector, it is crucial to conduct a thorough techno-economic evaluation, choose the appropriate technology, and establish a suitable project management system for both partners.

National standards

In terms of technical regulation, it is recommended to develop national standards for energy storage systems (ESS) in accordance with international standards, such as IEC (International Electrotechnical Commission) and ICC (International Code Council). Such national standards should regulate issues related to the parameters of ESS installations and testing methods; planning, installation, and efficiency evaluation of energy storage; guidelines on environmental issues and safe use of ESS, including fire safety, and other related aspects.

CONCLUSION

Energy storage systems (ESS) are becoming a crucial element of the energy system in Kazakhstan and Central Asian countries, aligning with the broader regional goals of developing clean energy and ensuring future energy security. In 2024, Uzbekistan successfully completed the installation of a battery energy storage system (BESS) for Energy China's 150 MW/300 MWh project in the Fergana region. ACWA Power, in collaboration with the authorities of Uzbekistan, plans to build large-scale renewable energy projects with a total capacity of over 1 GW, including energy storage systems in the Tashkent, Samarkand, and Bukhara regions, with a projected total capacity of over 1 GW. The acceleration of the implementation of progressive legislation and government support measures will make Kazakhstan more competitive and attractive to investors in the ESS sector.

Years Anniversary

Center for Energy and Advanced Materials Science, National Laboratory Astana, Nazarbayev University: Shaping the Future of Energy and Materials

THE CENTER FOR ENERGY AND ADVANCED MATERIALS SCIENCE (CEAMS) AT THE NATIONAL LABORATORY ASTANA (NLA), NAZARBAYEV UNIVERSITY, STANDS AT THE FOREFRONT OF SCIENTIFIC INNOVATION IN KAZAKHSTAN. AS A DYNAMIC HUB FOR INTERDISCIPLINARY RESEARCH, CEAMS IS DEDICATED TO ADDRESSING SOME OF THE MOST PRESSING CHALLENGES IN ENERGY, MATERIALS SCIENCE, HEALTHCARE, AND ENVIRONMENTAL SUSTAINABILITY. OUR MISSION IS ROOTED IN A DEEP COMMITMENT TO SCIENTIFIC EXCELLENCE AND NATIONAL DEVELOPMENT, GUIDED BY THE BELIEF THAT SCIENCE AND TECHNOLOGY ARE THE CORNERSTONES OF PROGRESS.

Dr. Arailym Nurpeissova, Dr. Yanwei Wang, Dr. Baktiyar Soltabayev, Dr. Nurxat Nuraje, Dr. Woojin Lee, Dr. Zhumabay Bakenov

NLA is home to state-of-the-art laboratories and world-class research infrastructure, enabling cutting-edge investigations across a wide array of scientific fields. In collaboration with international research institutions and universities, CEAMS advances pioneering solutions in green energy, smart materials, and energy-efficient technologies. Through these partnerships, our researchers contribute to global scientific progress while tailoring innovations to Kazakhstan's unique needs and resources.

In an era marked by the urgent need for energy transition and climate resilience, CEAMS plays a critical role in supporting Kazakhstan's vision for a sustainable and diversified economy. By leveraging the country's rich natural resources, such as rare earth elements and solar potential, and integrating advanced technologies, our research teams are developing impactful solutions for energy storage, carbon management, environmental remediation, and industrial safety.

Our long-term goal is to establish Kazakhstan as a global leader in scientific research and green innovation. To this end, CEAMS remains steadfast in its pursuit of breakthrough discoveries and practical applications that drive economic development, improve quality of life, and foster a cleaner, more resilient future. Through excellence in fundamental and applied science, we aim to shape not only Kazakhstan's scientific landscape but also the broader global discourse on sustainability and technology.

> Mission: To develop interdisciplinary fundamental, and applied research that addresses the nation's most pressing science and technological challenges in order to discover a new knowledge to promote the Kazakhstan's green economic and technological development, diversification of economy and to become a world-class institution well-known in research and technological excellence.

LABORATORY OF ENERGY STORAGE: ADVANCED BATTERY ENERGY STORAGE SYSTEMS

Kazakhstan is undergoing a major energy transformation, striving to balance rapid economic development with sustainability. As the nation taps into its abundant solar and wind energy potential, one of the most critical challenges is the creation of efficient and reliable energy storage systems. Addressing this challenge is essential for ensuring a stable power supply and minimizing reliance on fossil fuels.

The Energy Storage Systems Laboratory (ESS) at the National Laboratory Astana plays a central role in advancing the science of energy storage. Researchers at ESS are pioneering the development of next-generation lithium-ion batteries and supercapacitor systems that enhance energy storage efficiency, safety, and electrode longevity. These innovations are accelerating Kazakhstan's transition to a cleaner energy landscape and strengthening the reliability of its renewable energy infrastructure.

A particularly promising avenue of research at ESS involves the use of Kazakhstan's rich natural resources—especially its deposits of rare and rare-earth metals—for battery production. By incorporating locally sourced raw materials, the lab is working toward the development of sustainable, regionally adapted storage technologies that reduce import dependency and improve resource efficiency.

ESS is also at the forefront of developing rechargeable aqueous lithium-ion batteries (RALBs)—a safe and environmentally friendly alternative to conventional batteries. RALBs combine the energy density of commercial lithium-ion batteries with the safety of aqueous systems. They exhibit high cycling stability, lower production costs, and excellent safety profiles, making them highly suitable for large-scale applications such as grid storage and backup systems in industrial and residential settings [1].

In parallel, the lab is advancing microbattery technology to power compact electronics and microdevices. These miniature systems, composed entirely of solid electrodes and solid electrolytes, are a precursor to full-sized all-solid-state batteries—lithium-ion batteries without any liquid components. These solid-state variants promise superior safety and extended lifespan compared to their conventional counterparts [2].

Kazakhstan's harsh winters pose another unique challenge to battery performance, with sub-zero temperatures impairing conventional storage systems. To meet this need, ESS has developed low-temperature battery systems with advanced electrodes capable of maintaining high performance even in extreme cold [3,4] (Figure 1). This innovation is crucial for energy reliability in remote and off-grid regions of the country.

Another breakthrough initiative is the transformation of recycled plastics into battery components, addressing two global challenges simultaneously: plastic pollution and battery sustainability. This circular economy approach exemplifies Kazakhstan's growing commitment to green technology and responsible resource use.

To protect and commercialize its innovations, the ESS Lab holds a number of national and international patents.

By addressing key energy challenges, leveraging local mineral wealth, and driving innovation in sustainable technologies, Kazakhstan is charting a bold path toward a low-carbon future. The work at ESS not only enhances national energy security but also sets a global example of how targeted research can support the green transition for generations to come.

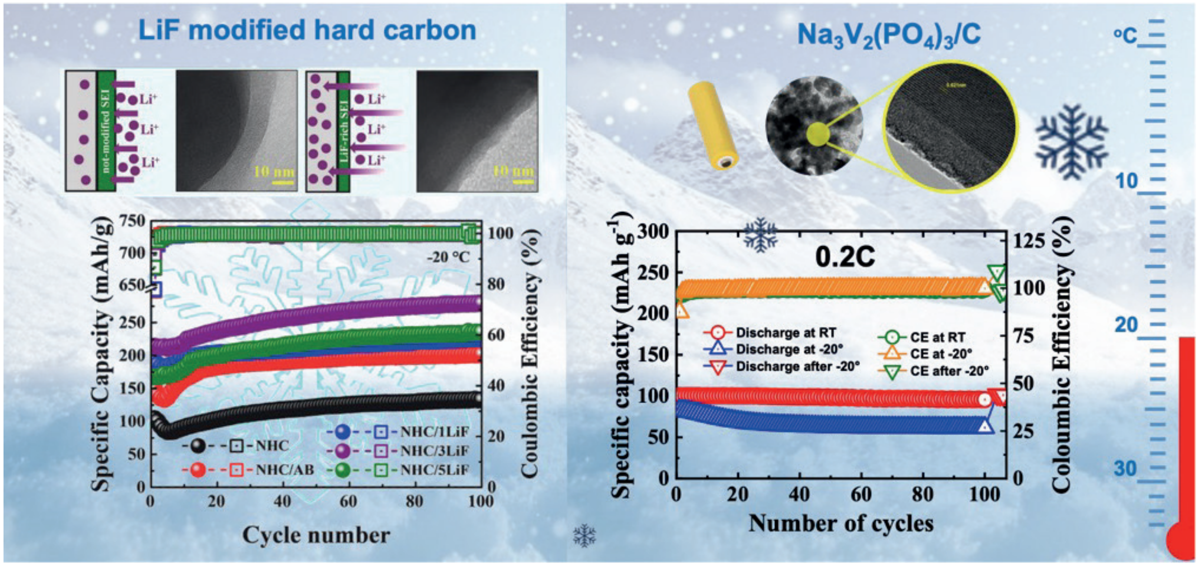


Figure 1. Developed low-temperature electrodes [3,4]

Computational Materials Science Laboratory: Accelerating Kazakhstan's Green Innovation through Computational Materials Science

As Kazakhstan and the world move toward a greener and more sustainable future, materials science is playing a quiet but crucial role, not through giant machines or futuristic infrastructure, but through digitalization and computational modeling that help us design better materials from first principles. At the CMS Lab, we use computational tools to study materials and processes across multiple scales, from atoms to systems, to accelerate innovation in clean energy and environmental technologies.

Rather than relying solely on trial-and-error experiments, we employ computational methods (illustrated in Figure 2) to predict structure–property relationships across a wide range of time and length scales, identify promising candidates, and uncover mechanisms not easily observed experimentally. By integrating insights across scales, we move faster, reduce waste, and focus resources where they matter most. Below, we highlight four directions in which our lab's computational work contributes to Kazakhstan's transition to a low-carbon and resource-efficient future.

Hydrogen Storage for a Clean Energy Economy: Hydrogen is an important part of Kazakhstan's clean energy strategy, particularly for decarbonizing transportation and industry. One of the key challenges is identifying materials that can store hydrogen safely, reversibly, and economically. At the CMS Lab, we use density functional theory (DFT) calculations and molecular simulations to evaluate binding energies and structural stability across candidate materials—from doped carbon nanostructures [5] to low-cost alloys. These studies offer atomic-level insight that supports the design of efficient, practical storage systems for hydrogen-powered technologies.

Radiation Effects in Ceramic Materials for Nuclear Systems: Silicon carbide (SiC) is a key material in advanced nuclear reactors, valued for its strength and thermal stability. However, radiation exposure can degrade its thermal transport properties. Using molecular dynamics and multiscale simulations, we investigate how extended defects—such as nano-layered stacking faults and interfaces—influence defect recombination and phonon scattering in irradiated SiC [6]. Our findings guide the design of more radiation-tolerant ceramic materials that better withstand the extreme conditions of next-generation nuclear energy systems.

Green Remediation Fluids for Polluted Soils and Aquifers: Environmental pollution from mining and oil operations presents a major challenge in Kazakhstan. We investigate gas-in-liquid dispersions stabilized by surfactants and polymers as soft-matter fluids for soil and groundwater remediation [7]. Using molecular simulations and AI-assisted image and data analysis, we examine their interfacial dynamics, stability, and flow behavior in porous media. These systems can be engineered to deliver oxidants or nutrients into contaminated zones with minimal environmental impact.

Biochar for CO2 Capture and Sustainable Agriculture: Biochar, produced from pyrolyzed agricultural waste, can capture carbon dioxide while also improving soil properties. We use DFT calculations and multiscale modeling to study how surface chemistry, doping, and pore structure affect CO2 adsorption [8] and interaction with soil minerals. Our work contributes to the design of multifunctional biochars tailored for long-term carbon retention and improved soil function, supporting both climate mitigation and land restoration in Kazakhstan—particularly in saline or degraded soils.

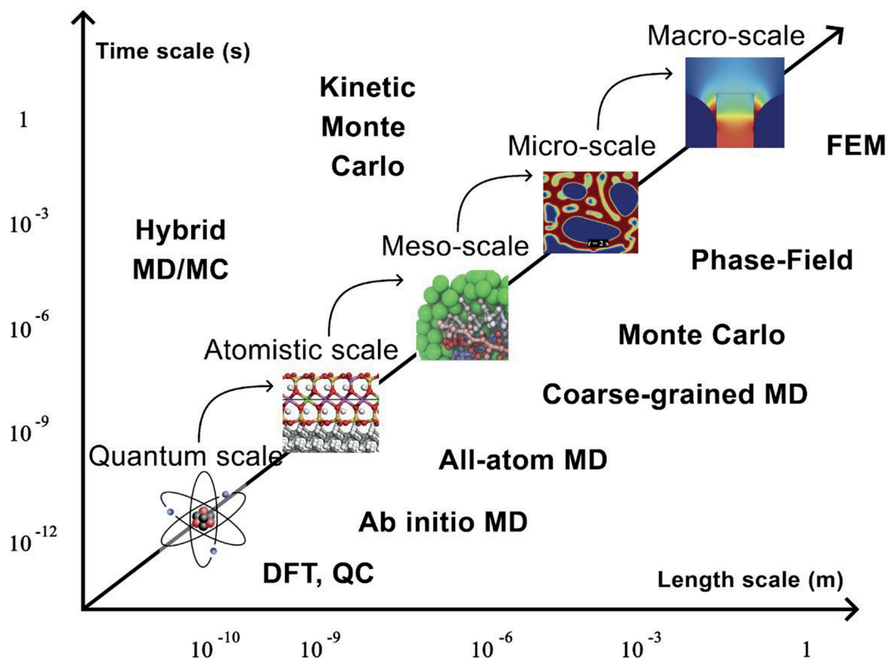


Figure 2. Multiscale modeling approaches in computational materials science, spanning quantum to continuum scales. Methods such as DFT, MD, kinetic Monte Carlo, phase-field, and FEM are used to link atomic-level mechanisms to system-level performance.

From hydrogen storage and radiation-tolerant ceramics to green remediation fluids and multifunctional biochar, our work at the CMS Lab demonstrates how multiscale modeling can drive real-world sustainability innovation. By integrating computational methods spanning quantum to continuum scales, we support the development of advanced materials and systems with precision and efficiency. As Kazakhstan moves toward a greener future, we believe that computation-guided science—spanning from atoms to systems—will remain essential to delivering cleaner, smarter technologies.

ADVANCED SENSORS LABORATORY: TOWARD A GREENER KAZAKHSTAN: ADVANCED GAS SENSORS FOR CLEANER AIR AND SAFER INDUSTRY

As Kazakhstan deepens its commitment to sustainable development and environmental stewardship, addressing industrial emissions and air quality becomes an urgent priority. With rapid expansion in the mining, oil, and gas sectors—alongside growing urbanization—the need for real-time, accurate gas detection is more critical than ever. At the Advanced Sensors Laboratory (ASL) of the National Laboratory Astana, our mission is to develop innovative gas sensor technologies that contribute to a cleaner, healthier, and safer environment.

Gas sensors may be compact and silent, but their impact is far-reaching. They serve as the invisible sentinels of modern society, monitoring toxic emissions, preventing industrial accidents, and enabling smart energy systems. The work of ASL is firmly rooted in this essential role—pushing the boundaries of sensor sensitivity, selectivity, and integration for applications ranging from environmental monitoring to industrial safety and energy optimization.

Figure 3. Scenes of urban air pollution: Industrial emissions, traffic congestion, and heavy smog contribute to poor air quality, affecting both the environment and public health.

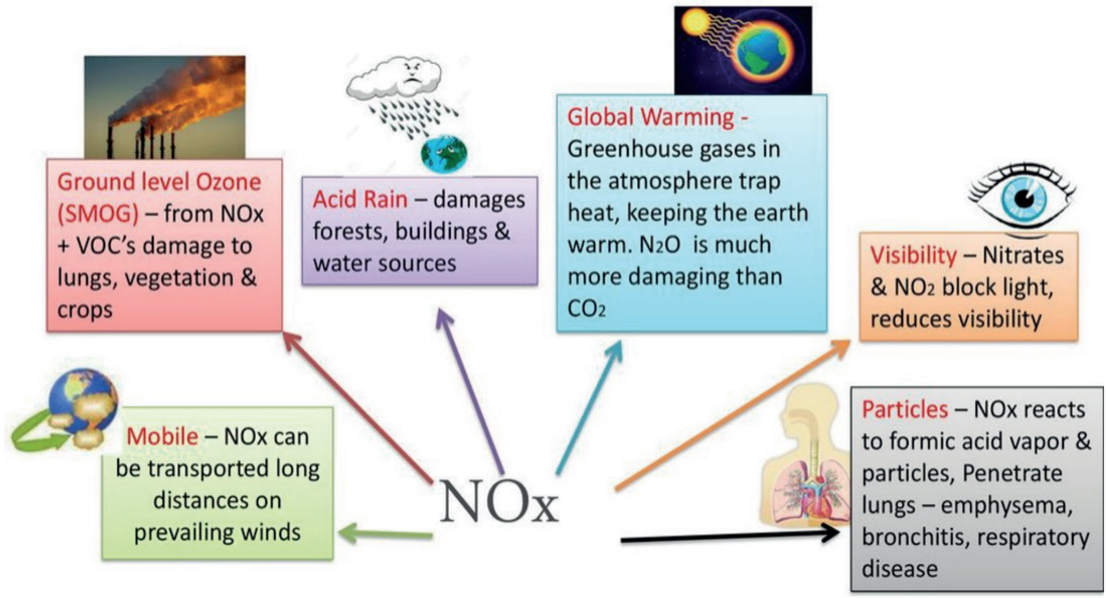


Figure 4. Effects of NOx pollution: harms air quality, health, climate, and the environment.

Why Gas Sensors Matter in a Greener Future

The rapid growth of the energy sector especially in mining, oil, and gas has led to a significant rise in emissions of harmful gases such as nitrogen oxides (NOx) and carbon dioxide (CO_2). These gases not only degrade air quality but also accelerate climate change, endanger public health, and compromise safety in industrial environments.

- NOx gases, for instance, contribute to the formation of ground-level ozone (smog), acid rain, and fine particulate matter. These pollutants are associated with respiratory diseases such as bronchitis and emphysema, while also harming forests, crops, and water systems.
- CO_2, the primary greenhouse gas, is a major driver of global warming. But lesser-known gases like nitrous oxide (N_2O) are far more potent and equally pervasive, highlighting the urgent need for accurate detection.

Innovating for a Safer and Smarter Future

At ASL, our mission is to develop highly sensitive, selective, and portable gas sensors capable of detecting hazardous and explosive gases in real time. These sensors are crucial not only for environmental monitoring but also for preventing industrial accidents in hazardous workspaces.

Our team has achieved notable breakthroughs in:

- Miniature gas sensors tailored for extreme environments in mining and oil industries.
- Self-powered sensors using integrated energy storage systems.
- Advanced nanomaterials like doped ZnO structures, enhancing sensitivity to gases such as H_2S, NO_2, and CO.

Through novel and advanced fabrication techniques, including magnetron sputtering and sol-gel deposition, we tailor sensor materials to optimize morphology, surface area, and gas adsorption capabilities. Real-world performance testing shows excellent gas response, selectivity, and durability across a wide range of operating conditions.

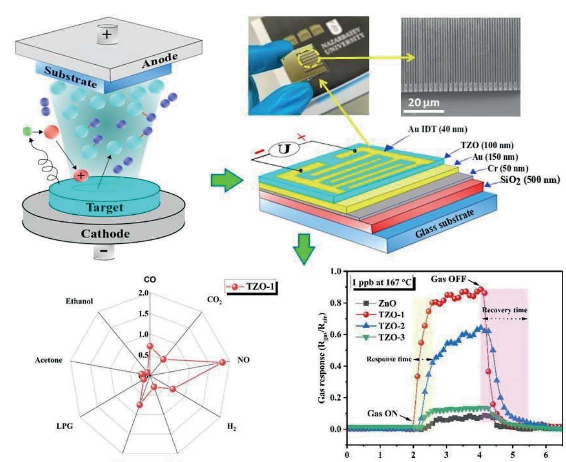


Figure 5. Fabrication and performance analysis of a TZO-based gas sensor: The schematic illustrates the deposition process, sensor structure, selectivity toward various gases, and real-time gas response behavior.

FROM LAB TO LANDSCAPE: GREEN TECHNOLOGY FOR A GREEN ECONOMY

These sensor technologies are more than laboratory curiosity; they are enablers of the green transition. Integrated into renewable energy systems, smart buildings, and industrial safety networks, our sensors help optimize energy use while monitoring emissions in real time.

By detecting leaks, measuring air quality, and triggering safety protocols, our innovations support the national vision for:

- Cleaner air in urban and industrial zones
- Safer workplaces in the energy and mining sectors
- Stronger compliance with environmental regulations
- A more resilient and green electric power sector

A Shared Commitment to Sustainability

As Kazakhstan works to expand its share of renewables and promote eco-conscious development, partnerships between academia, industry, and government are essential. At Nazarbayev University, ASL collaborates with local and international partners to bring sensor innovations into practical deployment, protecting lives, reducing environmental impact, and paving the way for a carbon-neutral future.

ENVIRONMENTAL SYSTEMS LABORATORY: SUSTAINABLE DEVELOPMENT WITH HIGH ENERGY EFFICIENCY

The Environmental Systems Laboratory (LES) at National Laboratory Astana focuses on sustainable development in environmental and energy sectors, addressing challenges pertinent to Kazakhstan and the global community.

Key Research Areas:

1. Sustainable Water/Wastewater Treatment & Environmental Catalysis:

- Development of advanced technologies for efficient contaminant removal while minimizing environmental impact.
- Synthesis and optimization of novel bimetallic catalysts supported by porous materials such as Metal-Organic Frameworks (MOFs), Zeolitic Imidazolate Frameworks (ZIFs), and zeolites.
- Effective elimination of heavy metals like Hg(II) and Cr(VI), as well as anions including NO_3^- and BrO_3^-.

2. CO_2 Conversion & Sequestration:

- Exploration of CO_2 conversion and sequestration technologies to mitigate greenhouse gas emissions.
- Interdisciplinary approaches encompassing geochemistry, electrochemistry, and modeling to assess the effectiveness of Carbon Capture, Utilization, and Storage (CCUS) strategies in Kazakhstan.
- Development of robust Life Cycle Assessment (LCA) protocols and assessment of resource potentials for hydrogen production.

3. Environmental Risk Assessment & Life Cycle Assessment:

- Comprehensive assessments to evaluate environmental risks and life cycles associated with infrastructure and contamination in Kazakhstan.
- Utilization of methodologies like LCA and stochastic human health risk assessment to quantify carbon emissions from urban water infrastructure and assess the impact of water and soil contamination.
- Provision of insights for developing environmental guidelines and improving existing regulations.

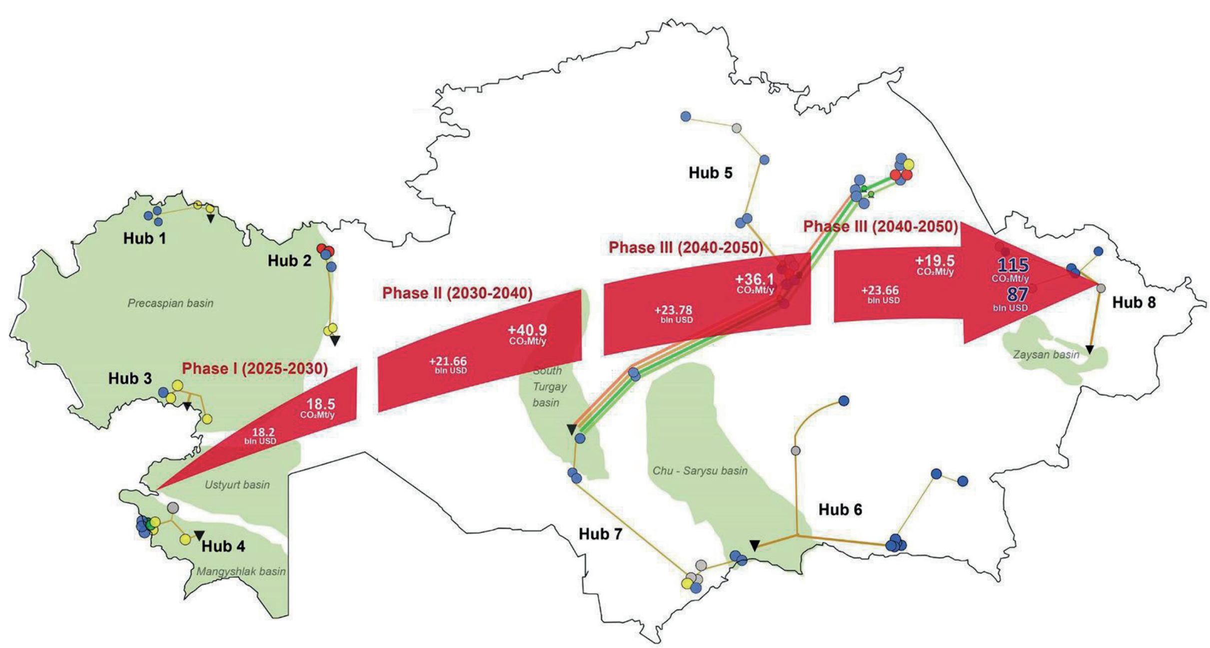


Figure 6. Carbon capture and storage (CCS) hubs development in Kazakhstan

Recent Research Outputs:
Development of Carbon Capture and Storage (CCS) Hubs in Kazakhstan:

- A study [9] published in the International Journal of Greenhouse Gas Control (October 2024) focusing on the establishment of CCS hubs to mitigate greenhouse gas emissions in Kazakhstan (Figure 6).
- Enhanced Reductive Removal of Aqueous Hg(II) by a Novel Pd-Cu-BTC and Co/NC Catalysts:
- Research [10] published in the Chemical Engineering Journal (June 2024) on the development of a novel catalyst for the efficient removal of mercury from water sources.
- Research [11] published in the ACS ES&T Engineering (January 2025) on the development of a novel catalyst regeneration approach during aqueous Hg(II) removal by Co/NC.
- Effect of Carbonized Zeolitic Imidazolate Framework-67 (ZIF-67) Support on the Reactivity and Selectivity of Bimetal-Catalytic Aqueous NO_3^- Reduction:
- A study [12] in Chemosphere (June 2024) examining how carbonized ZIF-67 supports influence the performance of bimetal catalysts in nitrate reduction processes.
- Microplastic contamination of municipal wastewater streams and its impact on the environment
- A study [13] published in Marine Pollution Bulletin (June 2024) provides the results on the concentrations and removal of microplastic throughout different wastewater treatment processes.
- A study [14] published in Science of The Total Environment (January 2025) examined the impact of microplastic containing wastewater streams discharge to the Ishim River.

Through these research endeavors, the LES aims to contribute significantly to environmental sustainability and the advancement of green technologies.

RENEWABLE ENERGY LABORATORY: TOWARDS GREENENERGY

The Renewable Energy Laboratory is a cutting-edge research facility dedicated to the design and development of novel solar-sensitive and multifunctional materials. The lab addresses both fundamental and technical challenges in various areas, including solar cells, solar fuels, hydrogen production, hydrogen storage, hydrogen sensing and value-added chemicals production including medicine from renewable resources.

The vision of the lab is to drive scientific progress in renewable and green energy and to create sustainable technologies for acleaner future.

The Renewable Energy Lab is recognized as one of the leading research facilities at National Laboratory Astana, Nazarbayev University. Kazakhstan is making significant strides in embracing renewable energy to diversify its economy and reduce carbon emissions. The country has set an ambitious goal of achieving 60% green energy by 2050. Investments in clean energy will play a crucial role in ensuring energy security, fostering sustainable growth, and creating a healthier environment for future generations.

President of the Republic of Kazakhstan Kassym-Jomart Tokayev has underscored the importance of this transition, stating: "The development of renewable energy is a key priority for Kazakhstan's sustainable future. We must harness our natural potential to ensure energy security, economic resilience, and environmental protection."

In alignment with this vision, the Renewable Energy Lab (NLA), has spearheaded the establishment of advanced Renewable Energy Laboratories to accelerate the shift toward sustainable power. These state-of-the-art research hubs are dedicated to exploring solar, wind, and energy storage technologies, leveraging Kazakhstan's abundant natural resources.

Key Research Areas:
Next generation photovoltaics team:

The research activity of the Next generation photovoltaics team is directed to the development of highly efficient, cost-effective and highly stable photovoltaic cells and devices as a source of renewable energy. The main objective of the team research includes third-generation solar cells such as dye-sensitized solar cells, perovskite solar cells and polymer solar cells. The tasks of the research cover improvement of the stability and power conversion efficiency of solar cells via applying engineering solutions and using low-cost materials and components.

To this day the research team has developed several best performing highly efficient and cost-effective counter electrode materials and light absorbing dyes for dye-sensitized solar cells. These findings were published in high-ranking journals including Surfaces and Interfaces, Dyes and Pigments, ACS Applied Energy Materials and Chemical Communications.

Recently the team has demonstrated a remarkable result in the improvement of dye-sensitized solar cells stability. By introducing metal-organic framework into the liquid electrolyte the stability of the solar cell was improved noticeably. Moreover, the dye-sensitized solar cell with MOF-based electrolyte and standard N719 dye showed record 27.6 % efficiency at indoor light conditions of 6000 lux under LED light. The results were published in a prestigious Nature Scientific Reports journal.

Hydrogen Production Team:

The core features and objectives of this project regarding the solar-driven hydrogen production via photocatalytic water splitting are highlighted in the

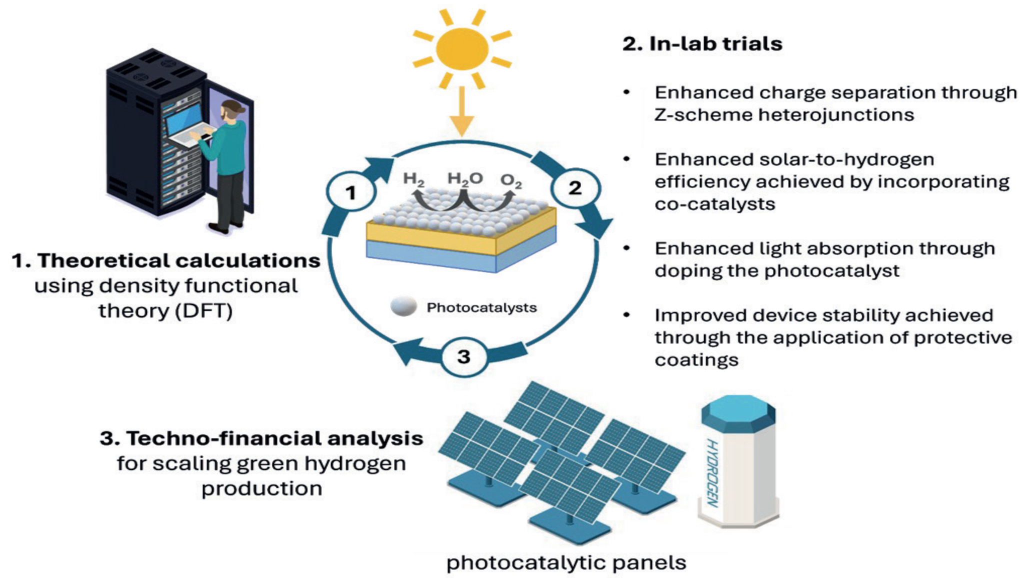


Figure 7. From theoretical to practical design implementation for improving renewable hydrogen technologies

figure above with a focus on advanced materials, computational modeling, and pilot-scale implementation. First, advanced computational tools, namely, density functional theory and machine learning, are used to design and simulate the behavior of photocatalytic materials. It helps to refine these materials' structure, light absorption potential and charge separation efficacy - all of which are vital in improving the photocatalytic water-splitting process. Second, the central section depicts in-lab trials, where the designed photocatalytic materials are synthesized and tested under controlled conditions to validate their performance after our hypothesized modifications such as doping, co-catalyst deposition, and protective coatings. Our latest study, published in Communications Materials (doi.org/10.1038/s43246-024-00574-5), emphasizes the importance of photonic design and optimization of photoelectrode systems for improving the light-harvesting property of photoactive materials. The central idea and the novelty of our work is the utilization of the whole solar spectrum which is possible due to the implementation of the upconverter device.

The last step brings the insights learned from material modeling and lab experiments to large-scale production. Process simulation software (e.g., Aspen Plus) is used to design these systems so that they are easily scalable and operationally feasible. Figure 7 summarizes the pathway from theoretical to practical design implementation as an integrated cycle for improving renewable hydrogen technologies.

The Hydrogen Storage Team focuses on studying solid-state hydrogen storage, which includes:

- Development of novel materials and composites for enhanced hydrogen storage.
- Utilization of biomass-derived activated carbon to improve hydrogen storage efficiency.
- Synthesis and optimization of high-surface-area MOFs such as MOF-177 and MOF-210 and their composites for enhanced hydrogen adsorption.
- Design of bimetallic ZIFs and metal hydrides, including TiFe alloy and alanates, for reversible hydrogen storage.

The main outcomes to highlight from this research group are that one patent is currently under review. Additionally, another patent and several research articles are in preparation by the Hydrogen Storage Team. These findings remain suitable for publication in Q1 journals; however, the team is striving to target even higher-impact journals.

Biomass Research Team

The Biomass Research Team focuses on the sustainable conversion of agricultural biomass into high-value products, including active pharmaceutical ingredients (APIs), biodegradable polymers, and bio-based fuels. Leveraging Kazakhstan's renewable resources, the team develops efficient and scalable synthesis methods using conventional, microwave-assisted, and flow chemistry approaches. Their research also includes catalyst optimization, high-yield product synthesis, and process integration. Life cycle and techno-economic analyses are conducted to ensure environmental and economic viability.

The team's research has been published in leading journals, including Chemical Engineering Journal and Scientific Reports. A utility model patent for a biomass processing method is under review

INSTITUTE OF PHYSICS AND TECHNOLOGY: RESEARCH AND TECHNOLOGIES FOR A SUSTAINABLE FUTURE

Klara Toxanbayeva,
Deputy Director for Commercial Issues, Institute of Physics and Technology

Institute of Physics and Technology (IPT) is one of the key research centers in Kazakhstan, engaged in fundamental and applied developments in the field of solid-state physics, nuclear physics, and modern technologies. Founded in 1990 by a decree of the Council of Ministers of the Kazakh SSR, it has undergone significant transformation and has become part of the Kazakh National Research Technical University.

Today, the IPT comprises nine high-tech laboratories working on such promising scientific areas as:

- research of innovative functional materials,
- study of photoelectric phenomena,
- development of heterojunction solar cells,
- radiation ecology,
- high-energy physics and cosmic rays, and much more.

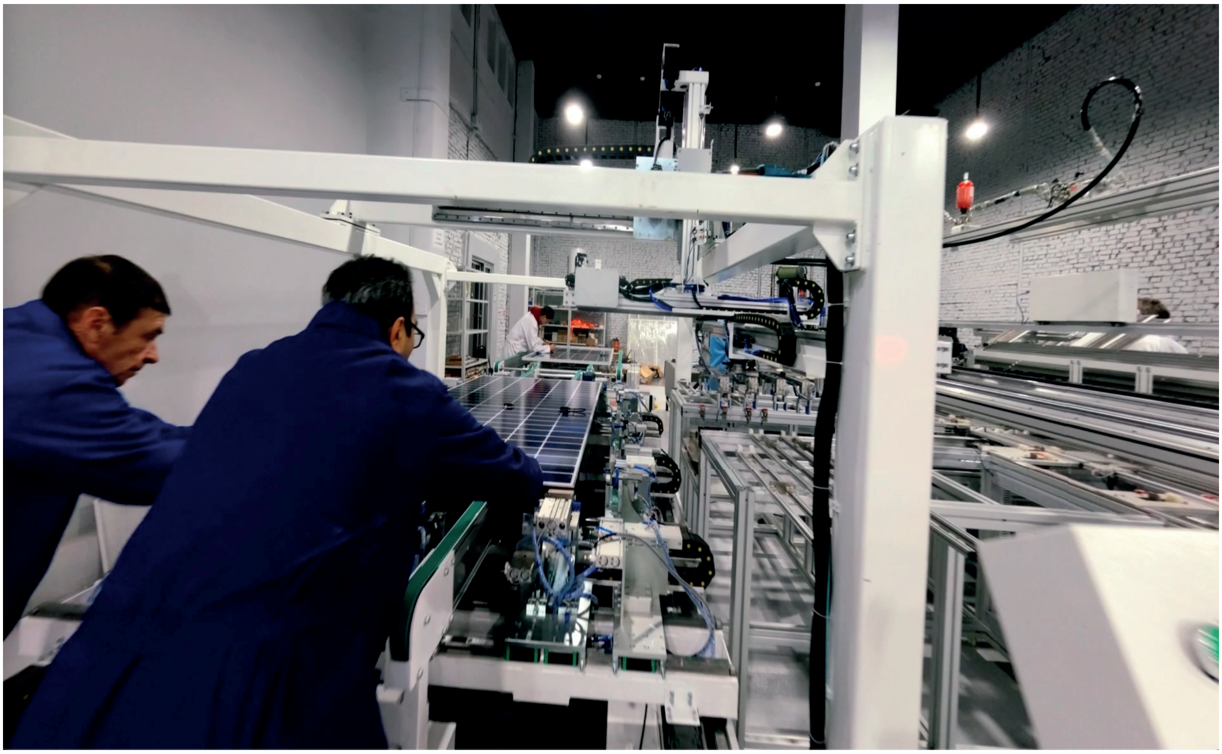
The Institute of Physics and Technology is actively engaged in the research and deployment of technologies related to renewable energy sources. For more than ten years, the development and optimization of heterojunction solar cells has been one of its principal areas of activity.

Heterojunction solar cells are innovative photovoltaic devices based on heterostructures — unique multilayer materials composed of different semiconductors. Each of these materials possesses distinct electrophysical and optical properties, enabling the formation of internal electric fields within the solar cell that directly affects the efficiency and performance of solar modules.

Heterojunction solar cells are innovative photovoltaic devices based on heterostructures — unique multilayer materials composed of different semiconductors.

An important milestone in the institute's development was the establishment of a pilot industrial facility for the production of photovoltaic modules. This made it possible to elevate scientific developments to a new level, i.e. from laboratory research to industrial application. The acquisition of the CT-KZ certificate confirmed the compliance of the products with high national standards and marked a significant step forward in the development of solar energy in Kazakhstan.

The Institute of Physics and Technology takes pride

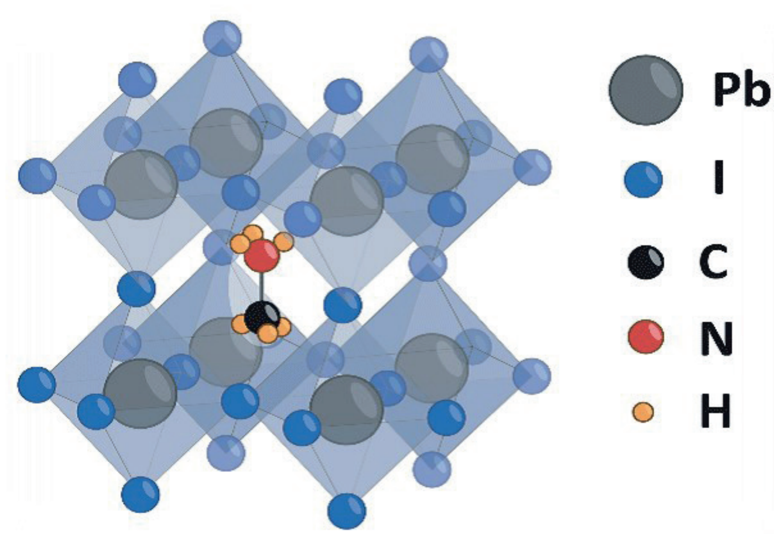


in the contribution of the scientists of Kazakhstan to the development of renewable energy. Significant progress in this field has been achieved thanks to the efforts of leading experts, including S.Zh. Tokmoldin, Doctor of Physical and Mathematical Sciences, N.A. Chuchvaga, PhD, N.S. Tokmoldin, PhD, V.V. Klimenov, I.S. Nevmerzhitsky, K.P. Aimaganbetov, PhD, K.S. Zholdybayev, S.R. Zhantuarov, A.K. Shongalova, PhD, and others.

Today, one of the key research areas of the institute is perovskite solar cells. These innovative photovoltaic devices have attracted the attention of the global scientific community due to their combination of high efficiency and low production cost. Unlike traditional silicon-based solar panels, perovskite solar cells are manufactured using organic compounds, which makes their production more cost-effective.

However, this technology faces significant challenges. The primary issue is its rapid degradation: while conventional silicon solar panels lose approximately 10% of their power over 25 years of operation, perovskite counterparts can lose up to 80% in just one day. Solving this issue is one of the main goals of ongoing research, and despite the hurdles, scientists believe perovskite solar cells are the future of solar energy.

The IPT is also focused on developing technology for producing and purifying silicon from Kazakhstan's sand deposits. Leading experts in this area include B.N. Mukashev, academician, Doctor of Physical and Mathematical Sciences, G.N. Chumikov, S.N. Tarakanova, N.M. Kislyakova, Y.A. Taraknov, S.S. Bazarbayev, A.S. Serikkanov, a candidate of physical and mathematical sciences, and others, who have contributed their time, expertise, and knowledge to this research. One of the recent breakthroughs is the production of electronic-grade silicon from slag. The research conducted as part of the project has led to the development of an efficient technology for producing and purifying silicon. This will make it possible to create a method for producing high-purity silicon for solar energy applications. The method will keep production costs low while being environmentally clean, in line with current standards for sustainable technologies. The slag produced during the silicon extraction process can be used for the production of high-grade slag-alkali cement.



https://www.nrel.gov/pv/assets/images/perovskite-1-model.gif

The laboratory technology for producing low-cost silicon offers several advantages over traditional purification methods. It requires fewer steps to achieve high silicon purity, significantly accelerating the purification process. Besides reducing processing time, this technology cuts production costs by optimizing resource use. A key factor is its environmental safety, making the process cleaner and minimizing its environmental impact. As a result, it allows for the production of solar-grade silicon with minimal costs and environmental impact.

Another promising area of research at the Institute of Physics and Technology is energy storage systems. A key topic in this field is Vanadium Redox Flow Battery. A.G. Umirzakov is the project leader for this direction.

THIS IS AN ENVIRONMENTALLY FRIENDLY LARGE-CAPACITY BATTERY CAPABLE OF DEEP CHARGING AND DISCHARGING. IT UTILIZES THE CHEMICAL POTENTIAL ENERGY OF VANADIUM IONS IN DIFFERENT OXIDATION STATES FOR ENERGY STORAGE AND EXHIBITS HIGH CHARGE AND DISCHARGE EFFICIENCY. THE ADVANTAGE OF HIGH SAFETY LIES IN THE FACT THAT THE CAPACITY CAN BE INCREASED BY EXPANDING THE STORAGE RESERVOIR, AND THE ELECTROLYTE CAN BE REUSED.

Using vanadium ion solutions V(II)/V(III) и V(IV)/V(V)as the positive and negative electrolytes, the battery's standard potential difference can reach 1.26 V, making vanadium a suitable material for energy storage (Figure 1).

• Fire safety

The active material of the vanadium redox battery is stored in separate liquid storage tanks outside the system as an aqueous solution. There is no risk of explosion or fire, and no danger even when the positive and negative electrolytes are mixed. The non-explosive nature of the battery is the most notable advantage of the vanadium redox battery (VRB) compared to other electrochemical batteries.

• Long service life

The positive and negative active materials of the VRB are located in the positive and negative electrolytes, respectively. No phase change occurs during charging and discharging. The battery can be deeply discharged without damage, and its lifespan can reach up to 20 years. At present, the VRB module with the longest operational time in the commercial demonstration of the energy system by the Canadian company VRB has been running smoothly for more than 9 years, with a charge and discharge cycle life exceeding 18,000 cycles, which is considerably higher than that of lithium and lead-acid batteries.

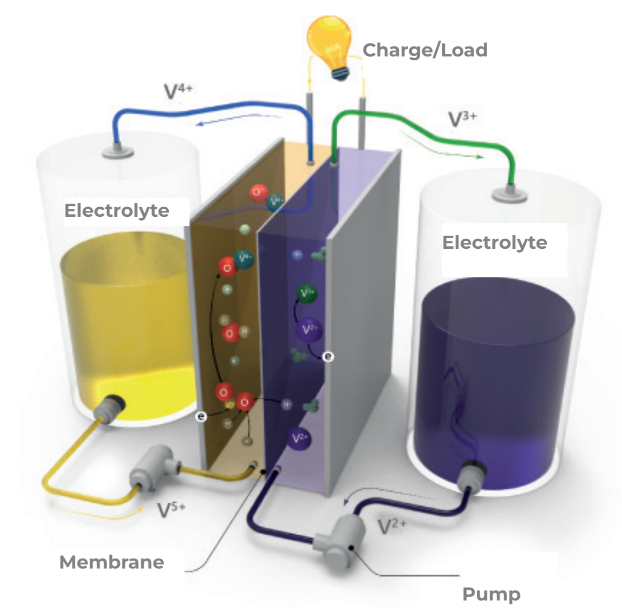


Figure 1 - Schematic of the operation of a vanadium battery.

• Large-scale energy storage is easily achievable.

The power and capacity of the vanadium redox battery depend on the size of the stack, and the volume and concentration of the electrolyte, respectively. Increasing the electrolyte concentration enhances the power, while increasing the electrolyte volume doubles the power. Therefore, vanadium redox batteries can be used in large-scale power plants for energy storage with capacities of hundreds of megawatts.

Disadvantages

• Low energy density.

Due to the relatively large atomic mass of vanadium, the energy density of the vanadium redox battery typically ranges from 12 to 40 Wh/kg, which is lower than that of lithium batteries, which range from 80 to 300 Wh/kg.

Therefore, to achieve the same energy reserve, the energy density of the vanadium redox battery is much lower than that of lithium batteries, specifically 3 to 5 times lower, which significantly complicates the use of vanadium redox batteries in mobile terminals and power batteries.

• Low energy conversion efficiency.

To maintain the flow of the electrolyte in the vanadium redox battery, a pump is needed, which results in significant energy losses. The energy conversion efficiency of the vanadium redox battery typically ranges from 70% to 75%, which is lower than the energy conversion efficiency of lithium batteries, which ranges from 85% to 95%.

• High initial installation cost.

The initial cost of installing a vanadium redox battery primarily consists of the stack and the electrolyte. Raw materials are relatively costly. Furthermore, the development of the vanadium redox battery industry is progressing at a relatively slow pace, and the industrial supply chain is imperfect. Currently, the initial installation cost ranges from 252 to 400 tenge per hour. This is more than twice the initial cost of the battery compared to lithium batteries, but in the long-term operation, these costs are compensated.

COMPARISON BETWEEN VRBS AND OTHER MAJOR BATTERIES. Vanadium redox batteries offer significant advantages over lithium, lead-acid, and other types in terms of service life, safety, and lifecycle cost. However, they still remain at a relatively disadvantageous position in terms of energy density, energy efficiency, and other factors.

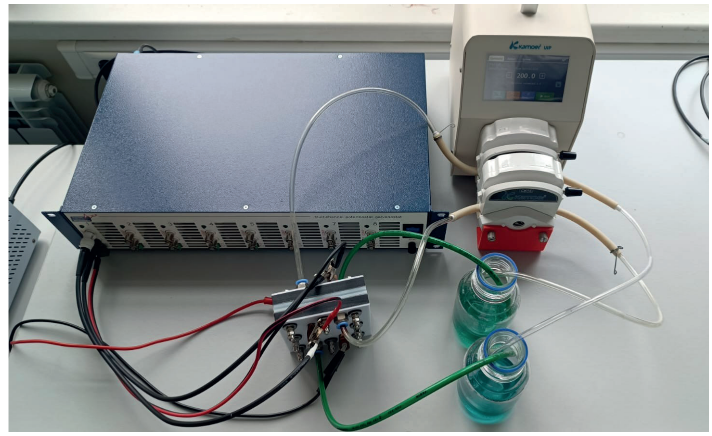
The operating principle of a vanadium redox battery differs from that of a lithium battery.

The vanadium redox battery has two electrolytes, one for the positive electrode and one for the negative electrode. The current is generated through the oxidation and reduction of vanadium ions, whereas in a lithium battery, the current is primarily generated by ion transfer.

The electrolyte in a vanadium redox battery is stored in separate reservoirs for the positive and negative electrodes. Under the action of a pump, the electrolytes are moved to the positive and negative electrodes of the stack. This design allows for the regulation of the capacity of the vanadium redox battery. The electrolytes are stored separately and do not react, which ensures high safety. In this regard, lithium batteries are significantly inferior to vanadium redox batteries.

The vanadium redox battery can be charged and discharged up to 15,000 times, while lithium batteries can be charged and discharged approximately 3,000 times, which is five times more than lithium batteries.

Moreover, the vanadium redox battery has a natural liquid cooling system. During operation, both the positive and negative



Testing of the laboratory sample of the flow battery.

electrolytes engage in chemical reactions and dissipate heat generated by the stack, helping maintain the battery at a moderate temperature. Lithium batteries have relatively low stability during prolonged charging, which leads to heating and increases the likelihood of ignition.

The vision of IPT is to ensure the sustainable development and competitiveness of the Institute as a leading scientific and innovative organization; to integrate itself into the global community through increasing the quantity and quality of publications in high-impact international journals.

The mission of IPT is to conduct a wide range of fundamental and applied research in the fields of solid-state physics and semiconductors, alternative energy, materials science, nanoscience, high-energy physics, and cosmic rays; to develop new samples and technologies based on this research, with subsequent implementation in scientific studies and production in the interests of the socio-economic development of the Republic of Kazakhstan.

Expanding the portfolio of scientific projects by involving the Institute in the implementation of state grants and attracting external projects for the execution of scientific and technological programs on R&D/innovation topics.

Vanadium battery assembly (IPT LLP).

A NEW PERSPECTIVE ON ENERGY GENERATION AND DISTRIBUTION FOR A SUSTAINABLE FUTURE

Life Is On | Schneider Electric

AS A GLOBAL INDUSTRIAL TECHNOLOGY LEADER, SCHNEIDER ELECTRIC BRINGS WORLD-LEADING EXPERTISE IN ELECTRIFICATION, AUTOMATION, AND DIGITISATION TO SMART INDUSTRIES, RESILIENT INFRASTRUCTURE, FUTURE-PROOF DATA CENTRES, INTELLIGENT BUILDINGS, AND INTUITIVE HOMES. IT HAS DEVELOPED TECHNOLOGIES THAT SUPPORT EFFECTIVE PROGRESS TOWARD A SUSTAINABLE FUTURE. IT IS IMPORTANT TO ACCELERATE THEIR IMPLEMENTATION.

THE ENERGY IS THE FOUNDATION OF A PROSPEROUS SOCIETY

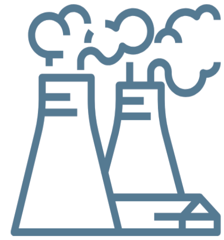
The energy is a basic need of humans, and its reliable supply is vital for economic progress. Alexander Nikiforov, leader of the Power&Grid segment in Central Asia, notes, "Energy also affects our habits and environmental impact. For example, the growth of the energy industry is associated with an increase in population and consumption culture and technology, which contributes to climate change. As the global economy grows, so does the demand for energy, driven by factors such as electrification, the growth of emerging markets, and the introduction of artificial intelligence. These changes are putting significant pressure on our energy system, underscoring the urgent need for its digitalization, decarbonization, and sustainability for a fair energy transition. This necessary energy transition also requires a change of mindset. Reducing carbon emissions, conserving water and resources, and ensuring reliability are important for growth today."

It's time to make bolder

IMPACT

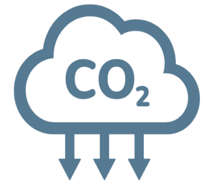
TOWARDS A NEW ENERGY WORLD

The methods of energy production and consumption are changing rapidly. The concept of a "prosumer" - both a consumer and a producer of energy - has transformed from a buzzword into a reality over the past two decades. New technologies enable customers to produce, consume and manage their own electricity: using energy generated from on-site solar panels and stored in batteries and electric vehicles. This approach not only allows the use of renewable energy, but also makes it possible to sell excess energy back to the grid. On a scale, it can provide a modular and affordable energy supply for businesses and society. For example, in the United States, 4.2 million homes have solar panels on their roofs as of February 2024. Throughout the year, a new solar panel installation project was implemented every 54 seconds. Technologies such as home energy management systems (e.g., Schneider Home), microgrids, distributed energy resource management systems (DERMS), combined with virtual power plants (VPP) and demand response programs (from companies such as Uplight), enable an integrated approach to the grid and prosumers — enabling utility service providers



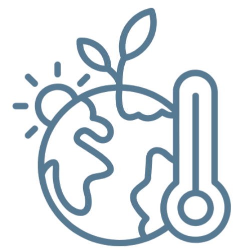
75%

greenhouse gas emissions generated by the energy infrastructure



90%

CO2 emissions due to the use of fuels - coal, oil and gas



2024

the warmest year on record

and energy providers to increase sustainability, lower costs, and reduce their carbon footprint to shape a more sustainable future.

1. Advanced power distribution systems
2. Digital twins
3. Micrograids
4. Distributed Energy Resource Management Systems (DERMS)
5. Virtual Power Plants (VPP)
6. Demand response programs

SMART TECHNOLOGIES AND ARTIFICIAL INTELLIGENCE – A NEW ERA OF EVOLUTION

As the energy world evolves with the growth of prosumer technologies and distributed energy resources, the traditional model is shifting to a bidirectional structure, creating a shared energy economy that ensures greater energy sustainability and harmonious development of our communities. The backbone of this evolution is the electric grid, which

Life Is On | Schneider Electric

Schneider Electric believes that AI will be at the center of the modern electric grid, using the vast amount of data collected to develop predictive models of energy production and consumption and manage distributed resources accordingly.

needs to be upgraded to support future energy needs and our vision of a clean energy future. But upgrading a network is a complex, expensive, and time-consuming process. To achieve the countries' climate and energy goals, 80 million kilometers of transmission lines will need to be added or replaced by 2040, which will require significant operational and regulatory changes and a doubling of network investments to more than $600 billion annually by 2030. This task will require a comprehensive technological approach. We have implemented a number of projects at the facilities of our customers and partners using our EcoStruxure solutions with Internet of Things support in various segments, including buildings, utilities and data centers.

We use innovative technologies that accelerate the energy transition, such as virtual power plants, which are networks of energy resources to power the grid. They can quickly add significant backup power and flexibility to the network, and when integrated into an advanced distribution management system, the resulting automation becomes revolutionary.

DEVELOPING THE ENERGY FUTURE

"Kazakhstan's energy sector plays a key role in the country's economy. In recent years, the Government has been actively implementing measures to ensure reliable energy supply and the transition to environmentally friendly energy sources. Kazakhstan is actively developing renewable energy sources (RES). Today, there are more than 100 RES facilities in the country. An important project was to strengthen the electrical network of the Western Zone, which increased the reliability of power supply. The next step is planned to connect electric networks, which will improve the transit potential. These initiatives and projects demonstrate Kazakhstan's commitment to sustainable development and global transition to a low-carbon model. Given the existing global references, we would like to use the experience of international companies more actively. The introduction of advanced solutions, such as technologies from Schneider Electric, can significantly improve the quality of life and contribute to the development of the country's energy sector," Alexander Nikiforov added. Schneider Electric believes that AI will be at the center of the modern electric grid, using the vast amount of data collected to develop predictive models of energy production and consumption and manage distributed resources accordingly. But to make the energy transition a reality, we need the collaboration of the entire ecosystem. The utility service providers, grid operators, energy management companies, industry, and prosumers must take steps that transform energy connections, ultimately benefiting business, society, and our planet.

CHALLENGES AND PROSPECTS OF GREEN TRANSFORMATION IN KAZAKHSTAN

ALTHOUGH KAZAKHSTAN POSSESSES ONE OF THE LARGEST WIND AND SOLAR ENERGY POTENTIALS GLOBALLY, IT STILL DEPENDS ON COAL AND OIL. DESPITE POLITICAL DECLARATIONS — FROM THE "KAZAKHSTAN–2050" STRATEGY TO THE GOAL OF CARBON NEUTRALITY BY 2060 — ACTUAL PROGRESS IN DEVELOPING RENEWABLE ENERGY SOURCES HAS BEEN SLOW. WHY?

Although Kazakhstan possesses one of the largest wind and solar energy potentials globally, it still depends on coal and oil. Despite political declarations — from the "Kazakhstan–2050" strategy to the goal of carbon neutrality by 2060 — actual progress in developing renewable energy sources has been slow. Why?

A study conducted by an expert group has identified systemic barriers in Kazakhstan that are hindering the green transition. The findings paint a clear picture: without structural legal reforms, technological modernization, and well-designed financial support, a sustainable energy future cannot be achieved.



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Anel Nurkanat, Astana IT University

Shynar Zhusupkaliyeva, Astana IT University

Ayagoz Khamzina, Astana IT University

Table 1. Classification of barriers

Category	Barriers
Political and Regulatory	Low tariff for electricity generation from fossil fuels Lack of vision for integrating generated capacities from renewable energy sources (location, years of commissioning) Unexplored prospective areas for deploying renewable energy facilities, no designated lands for these purposes
Financial	Insufficient funding for renewable energy projects Lack of exploration of opportunities for local manufacturers, no market demand signals
Technological	Outdated electricity production infrastructure Underdeveloped local production of renewable energy equipment and components Limited experience in developing and implementing localization of production components Undeveloped networks, undefined connection points, and maximum connectable capacities of renewable energy source
Social	Lack of interest from the population in developing energy-efficient technologies Lack of adequately trained professionals in the renewable energy sector.

Barrier significance to renewable energy development by stakeholder groups

Category	Barriers	SES(%)	WES(%)	HES(%)
Technological	Outdated electricity production infrastrructure	43,3	47,1	40
	Underdeveloped local production of renewable energy equipment and componenets	60	41,2	60
	Limited experience in developing and implementing localization of production componenets	70	35,3	80
	Undeveloped networks, underfined connection points, and maximum connectable capacities of renewable energy sources	43,3	52,9	60
Financial	Lack of exploration of opportunities for local manufacturers, no market demand signals	23,3	17,6	40
	Insufficient funding for renewable energy projects	56,7	41,2	20
Social	Lack of interest from the population in developing energy-efficient technologies	50	47,1	40
	Lack of adequately trained professionals in the renewable energy sector	56,7	52,9	20
Policy and Regulatory	Low tariff for electricityy generation from fossil fuels	73,3	76,5	40
	Lack of vision for integrating generated capacities from renewable energy sources (location, years of comissioning)	46,7	47,1	60
	Unexplored prospective areas for deploying renewable energy facilities, no designated lands for these purposes	33,3	52,9	20

Although there is both political will and economic motivation, Kazakhstan's shift to renewable energy continues to face entrenched systemic obstacles. An analytical survey of 54 experts allowed for the classification of these barriers into four main categories (Table 1).

Table 2. Classification of risks

Category	Risk
Market risks	Significant technological lag of Kazakhstan in the field of renewable energy Continuation of low tariffs for traditional electricity generation Decreased purchasing power of vulnerable population segments
Political risks	Decrease in the country's investment attractiveness Decrease in foreign investments Potential changes in Kazakhstan's legislation that could negatively affect corporate activities
Liquidity risks	Tying up funds in large-scale investments in the development of the renewable energy
Operational risks	Unpreparedness of manufacturing organizations for the production of renewable energy components Disruption in the supply of foreign components for renewable energy Global climate change and an increase in the frequency of abnormal weather phenomena

Key risks impacting renewable energy development in Kazakhstan

Category	Risks	Risk impact (%)
Market risks	Significant technological lag of Kazakhstan in the field of renewable energy	66,7
	Continuation of low tariffs for traditional electricity generation	55,6
	Decreased purchasing power of vulnerable social groups	59,3
Political risks	Decrease in country's investment attractiveness	57.4
	Decrease in foreign investments	42,6
	Possible changes in Kazakhstan"s legistation that could negatively affect corporate activies	64,8
Operational risks	Unpreparedness of manufacturing organizations for the production of renewable energy components	55,6
	Disruption on the supply of foreign componenets for renewable energy	53,7
	Global climate change and an increase in the frequency of abnormal weather phenomena	46,3
Liquidity risk	Tying up funds in large-scale investments in the development of renewable energy	42,6

According to the results of an expert survey, the key risks hindering investments in Kazakhstan's renewable energy sector are technological lag, which 66.7% of participants identified as the main obstacle; unpredictability of legislation, which creates uncertainty and can undermine investors' efforts; and high initial costs, particularly in wind energy. For investors, the most critical risks turned out to be macro-level risks — political and market risks, rather than operational ones (see Table 2).

Barrier significance to renewable energy development by stakeholder groups

Category	Barriers	High (%)	Moderate (%)	Low (%)
Technological	Outdated electricity production infrastrructure	53,7	14,8	18,5
	Underdeveloped local production of renewable energy equipment and componenets	57,4	25,9	7,4
	Limited experience in developing and implementing localization of production componenets	53,7	27,8	9,3
	Undeveloped networks, underfined connection points, and maximum connectable capacities of renewable energy sources	48,1	37	3,7
Financial	Lack of exploration of opportunities for local manufacturers, no market demand signals	35,2	44,4	11,1
	Insufficient funding for renewable energy projects	50	27,8	9,3
Social	Lack of interest from the population in developing energy-efficient technologies	51,9	24,1	13
	Lack of adequately trained professionals in the renewable energy sector	40,7	42,6	9,3
Policy and Regulatory	Low tariff for electricityy generation from fossil fuels	66,7	20,4	5,6
	Lack of vision for integrating generated capacities from renewable energy sources (location, years of comissioning)	46,3	27,8	13
	Unexplored prospective areas for deploying renewable energy facilities, no designated lands for these purposes	38,9	33,3	9,3

The research revealed that each sector of renewable energy in Kazakhstan faces distinct barriers: the solar energy sector struggles the most due to regulatory uncertainty and insufficient experience in local production; the wind energy sector is hindered by limited access to power grids and a critical shortage of qualified specialists; while hydropower is heavily dependent on natural conditions and suffers from the absence of clear strategic planning at the government level.

While Kazakhstan has developed a legal framework for green financing and initiated the issuance of green bonds, the majority of experts argue that access to financial instruments remains constrained. Only 25.9% consider green bonds to be genuinely accessible. Over half of the experts struggled to provide an assessment, reflecting a lack of awareness.

Experts suggest that to expedite the development of renewable energy in Kazakhstan, it is necessary to ensure government guarantees to mitigate investment risks, provide long-term financing in the national currency at reduced interest rates, introduce technical guarantees for grid connections, support the development of local renewable energy component manufacturing, and implement large-scale programs aimed at increasing public awareness and training qualified specialists.

Kazakhstan finds itself at a pivotal moment: it must choose whether to continue depending on coal infrastructure or make a bold move toward a sustainable future. The country possesses immense potential in solar, wind, water, and, crucially, a growing interest in renewable energy among both professionals and the public. However, for success to be achieved, transparent regulations, access to financing, and seamless collaboration among all stakeholders are essential.

As highlighted in the article, a sustainable energy transition cannot be achieved without robust institutional support, technological advancement, and public engagement. This is the only way Kazakhstan can emerge as a leader in green energy in Central Asia.

THE SECOND LIFE OF ORGANIC WASTE IN GERMANY

THE GERMAN WASTE MANAGEMENT MODEL IS ONE OF THE MOST EFFICIENT IN THE WORLD. ITS SUCCESS IS BASED ON THREE KEY ELEMENTS: SEPARATE COLLECTION, WELL-DEVELOPED INFRASTRUCTURE AND ENVIRONMENTAL EDUCATION. BUT THE MAIN THING IS NOT JUST RULES, BUT A SYSTEM OF INCENTIVES. THE STRICT LEGISLATION AND HIGH TARIFFS MAKE RECYCLING PROFITABLE, WHILE IRRESPONSIBLE WASTE MANAGEMENT IS MONEY-LOSING. THIS APPROACH NOT ONLY REDUCES THE BURDEN ON NATURE, BUT ALSO CREATES A CULTURE OF CONSCIOUS CONSUMPTION AMONG CITIZENS AND BUSINESSES.

Ardak Zhakezhanova,
Lead Expert of KazWaste (Kazakhstan Waste Management Association)

Sholpan Talgat,
PR Manager at KazWaste (Kazakhstan Waste Management Association)

In German, organic waste is referred to by various terms: „Organik“, „Bioabfälle“, „biogene/biologische Abfälle“, „Bio-/Grüngut“.

This category includes food industry waste, food residues, kitchen waste (both private and commercial), as well as garden and park waste.

A characteristic feature of food waste is its high humidity, which is why it has a significant weight.

High-quality organic waste is a prerequisite for efficient recycling. The properly sorted organic waste with a low content of impurities only can be used to produce high-quality compost suitable for agriculture and horticulture.

Separate collection of organic waste began in Germany back in 1985.

Mandatory requirements for separate waste collection have been in effect since January 1, 2015.

Legislative regulation of organic waste processing

Waste management in Germany is regulated by the regulatory requirements of the Federal Environmental Protection Agency (Umweltbundesamt), which establish rules for the collection, disposal and recycling of waste. These standards are aimed at ensuring environmentally sound waste management and efficient use with minimal impact on nature.

In Germany, the requirements for the composition and quality of organic waste compost are set out in the Organic Waste Ordinance (Bioabfallverordnung, BioAbfV). This regulation monitors the treatment, application and control of organic waste, especially with regard to its use in agriculture and horticulture. According to this Regulation, the maximum content of impurities, such as plastic or glass, in compost should not exceed 0.5% by weight of dry matter. This requirement is aimed at ensuring high-quality compost and preventing soil contamination during its use.

Special regulation applies to organic waste containing materials of animal origin, such as eggs, milk, meat and bones. They are subject to the Law on the Removal of Animal By-products ("Tierische Nebenprodukte-Beseitigungsgesetz"), which ensures hygiene standards and prevents the spread of pests.

According to this Regulation, the maximum content of impurities, such as plastic or glass, in compost should not exceed 0.5% by weight of dry matter.

ORGANIC WASTE RECYCLING METHODS IN GERMANY

In Germany, organic waste is processed using various technologies that make it possible to efficiently dispose of raw materials and obtain valuable products.

The Cogeneration plants (Biomasseheizkraftwerk) recycle organic waste, converting it into energy and ash, which can be used as fertilizer.

Biogas plants (Biogasanlage) produce biogas and fermented residues (Gärrest) suitable for agriculture.

The composting (Kompostieranlage) allows turning organic waste into high-quality compost that enriches the soil.

The organic waste is classified according to its structure and moisture level:

Solid, structure-rich plant material, moderately moist.

Easily digestable, little structure, solid to liquid (i. e. food wastes).

Dry, wood-rich plant material, i.e. wood cuttings.

Thanks to these recycling methods, organic waste is converted into energy, fertilizers and useful resources, reducing the burden on the environment.

BIOCONVERSION OF ORGANIC WASTE

Bioconversion is the process of converting organic raw materials (plant and animal waste) into useful products or energy sources using biological processes and microorganisms. This method makes it possible to efficiently dispose of organic waste, minimizing its impact on the environment.

One of the most innovative examples of bioconversion is the use of Black Soldier Fly larvae. They recycle organic waste, turning it into high-protein feed for farm animals and fish. This approach not only reduces food waste, but also contributes to the development of sustainable feed production systems.

The biogas industry in Germany deserves special attention. Biogas plants in this country convert organic waste into clean energy, heat and fertilizers, providing not only efficient processing, but also a significant reduction in greenhouse gas emissions. This plays an important role in the global fight against climate change.

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Germany is actively improving the legislative requirements for the development of the biogas industry. According to the amendments to the Law on Renewable Energy Sources, by 2030, 80% of the energy consumed should come from renewable sources. In particular, the capacity of biogas plants is planned to be increased from 5,600 MW in 2024 to 8,000 MW. These ambitious goals are supported by significant investments and government programs, which strengthen the country's environmental sustainability.

Germany's experience in processing organic waste is an excellent example for Kazakhstan.

Kazakhstan has a huge potential for the processing of organic waste and the development of the biogas industry due to the developed agriculture, which annually produces significant amounts of organic waste: animal wastes, crop residues and processing of agricultural products.

The issues of reducing the volume of organic waste disposal and the introduction of effective methods of their processing are also one of the urgent issues for Kazakhstan.

With the use of advanced recycling technologies, the creation of efficient infrastructure and the introduction of government support mechanisms, the recycling of organic waste can take a key place. This will reduce the load on landfills, reduce greenhouse gas emissions and improve the environmental situation in the country.

Sources:
1. Laura Scherer, Circu:Culture, Introduction to Waste Management in Germany.
2. The Berg Waste Management Association (Bergischer Abfallwirtschaftsverband).

PROSPECTS FOR THE DEVELOPMENT OF THE CORPORATE RES PPA CONTRACTS MARKET

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

Bilateral (corporate) RES contracts are agreements governing the sale and purchase of electric power between a renewable energy producer and a consumer at a pre-agreed price and for a certain period of time. In this case, the long-term buyer of electric power from renewable energy sources is the consumer.

The main goal of developing bilateral RES contracts is to create an opportunity for buyers to independently choose the source of production of electric power consumed, while the electric power RES producer gets the opportunity to plan financing for its activities. It should also be noted that bilateral RES contracts allow us to solve the following tasks:

– No dependence on a single electric power purchaser;

– Determination of the fair value of electric power;

– The ability to hedge risks from changes in legislation to support RES and international requirements to reduce the carbon footprint;

– Fulfillment of environmental obligations by the buyer of electric power;

– Organization of long-term planning for the purchase and sale of electric power for the buyer and seller, respectively;

– One of the solutions to reduce the negative impact of RES on the energy system.

PAYMENT FOR ELECTRIC POWER

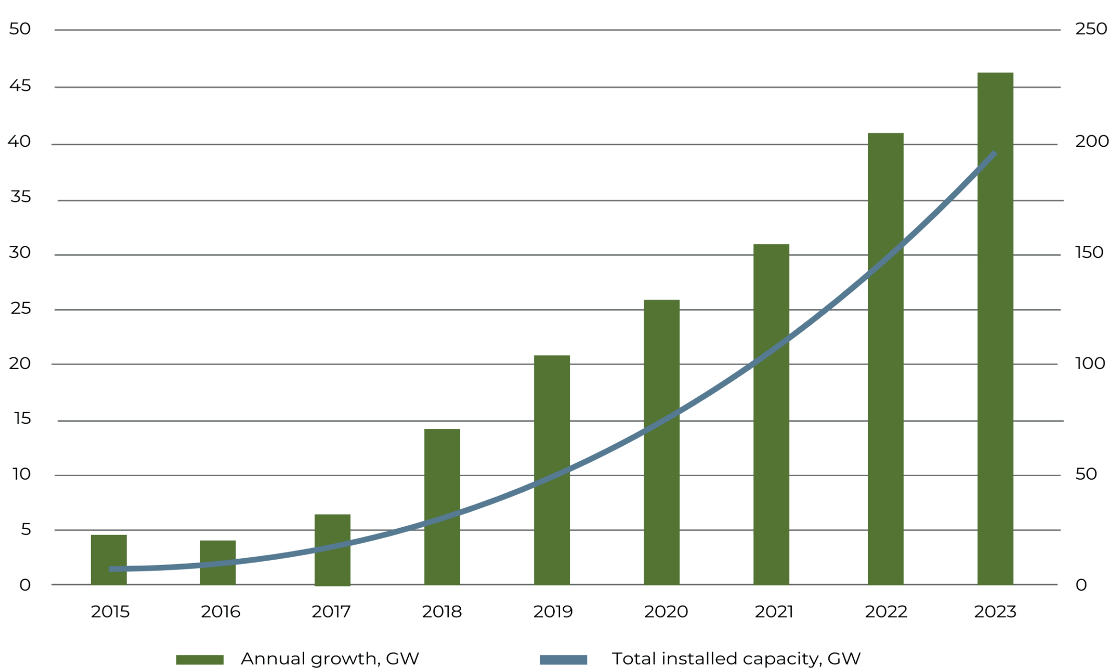
Source: Qazaq Green RES Association

According to a report by BloombergNEF, corporations have publicly announced 46 GW of [1] solar and wind power purchase agreements (PPAs) in 2023, up 12% from the previous year.

Between 2022 and 2023, the volumes of corporate PPAs in Europe increased by 74% up to 15.4 GW. It was the largest increase among all regions. BloombergNEF reported that as "supply chain issues have softened and gas balances have returned to normal following the region's energy crisis in 2022, corporate PPAs prices in the region have been falling, often faster than electric power prices."

The United States remains the largest market for electric power purchase agreements (PPAs), with 17.3 GW of announced transactions, but year-on-year volume decreased by 16% compared to the record 20.6 GW achieved in 2022.

Diagram X – Volumes of corporate PPAs



Source: BloombergNEF

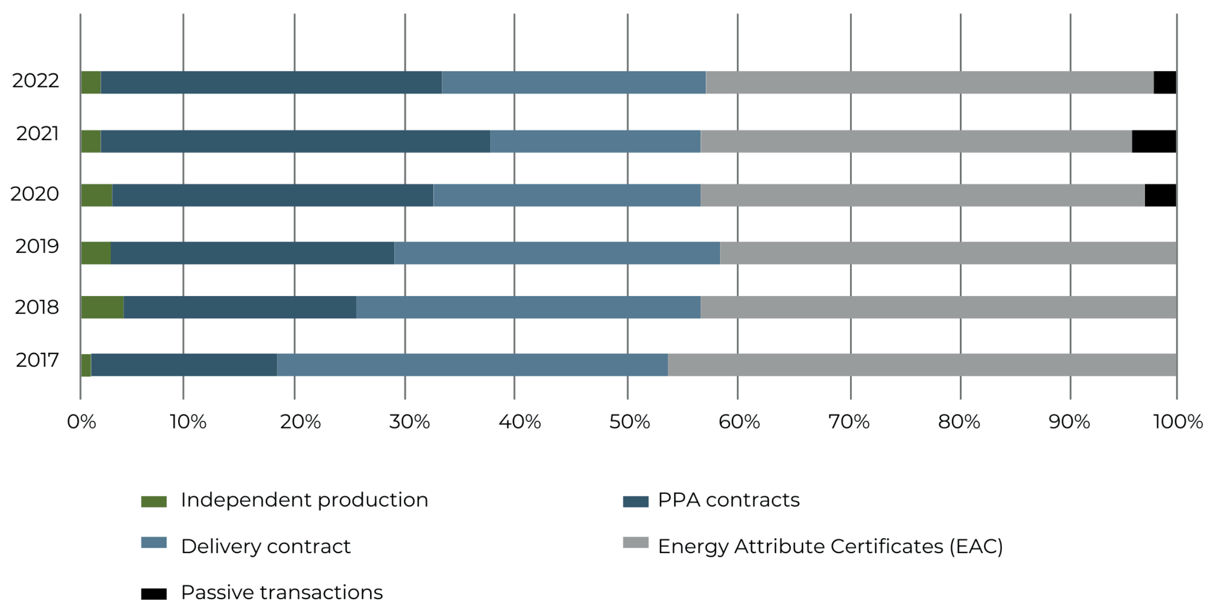
[1]BloombergNEF (BNEF) in its 1H 2024 Corporate Energy Market Outlook

In order to promote renewable energy sources, large corporations and companies around the world have joined together in the RE-100 initiative. The RE100 is a global corporate renewable energy sources initiative that brings together hundreds of large and ambitious companies committed to the principle of 100% renewable energy use. The RE100 member companies are already providing enough demand for renewable electric energy to power a medium-sized country.

The RE100 unites more than 420 large companies, including Apple, Airbnb, Samsung, Adobe and others. At the moment, RE100 companies have purchased 440 TWh of clean electric power and are striving to achieve 100% carbon-free electric power consumption by 2040.

By the end of 2022, 31% of RE100 companies purchased renewable electric energy through the mechanism of bilateral PPA contracts. The reporting distinguishes between physical and virtual PPAs, as well as between retail and project contracts with electric power suppliers.

Diagram X – Volu Diagram X – The structure of the purchase of the RES electric power by RE-100 companies mes of corporate PPAs



Source: RE-100 Annual disclosure report 2023

About 41% of the transactions for the purchase of electric power by members of the RE-100 initiative were carried out through the purchase of Energy Attribute Certificates. They are usually sold by third-party retailers that do not supply physical electricity. However, in all these cases, EAC customers consume electricity from the grid and use certificates to substantiate claims about renewable energy consumption and emission reduction.

Amazon has become the world's largest corporate buyer of clean energy for the fourth year in a row. It announced 8.8 GW of PPAs in 16 countries, including 5.6 GW of solar PPAs. The company's clean energy portfolio is 33.6 GW, which is larger than the electricity generation parks in markets such as Belgium and Chile. Amazon is followed by Meta, which announced 3.1GW of PPA in solar power.

According to BloombergNEF, companies aiming for 100% clean energy through the RE100 initiative will need an additional 105 GW of solar and wind power by 2030.

According to the forecast of the International Energy Agency, by 2030,[2] corporate PPAs will be the second most important factor in the development of the RES after competitive auctions. To date, about 20% of the increase in the RES capacity in Spain, Italy, Poland, Sweden, Germany, France, Great Britain and Denmark belongs to the corporate sector. Such corporate PPAs in European countries are attractive mainly because they provide long-term visibility of electric power prices for large industrial consumers seeking to insure themselves against fluctuations in retail tariffs.

The implementation of corporate PPAs is also facilitated by the electric power market reform carried out in April 2024[3]. The main amendments adopted by the European Parliament include encouraging long-term contracts for the supply of non-fossil energy, the introduction of cleaner and more flexible solutions and increased market transparency. Thus, one of the innovations is bilateral contracts for difference (CFDs) for new investments in low-carbon energy production, where government financing is needed. This means that national authorities coordinate with electricity producers pre-determined ranges of energy prices. This is beneficial to everyone: the manufacturer can be sure that he will be able to sell energy at a predictable price, while providing his consumers with the necessary amount of energy. In areas where bilateral contracts for difference are irrelevant, electric power purchase agreements (PPAs) are promoted. They also have the effect of creating long-term stability.

Additional demand for corporate PPAs is expected from existing energy-producing organizations using renewable energy sources, whose support periods expire in the coming years.

Development of corporate PPA contracts in Kazakhstan

In accordance with the legislation of the Republic of Kazakhstan, the following standards are fixed:

1. "On support for the use of renewable energy sources" Law of the Republic of Kazakhstan dated July 4, 2009 No. 165-IV (subparagraph 2 of Article 9 of the Law) – "1. An energy producing organization using renewable energy sources has the right, at its discretion, to sell the produced electric power according to one of the following options:

1) to a single buyer of electric power at a fixed tariff effective on the date of conclusion of the purchase and sale agreement between the energy producing organization and the settlement and financial center, or at an auction price determined based on the results of the auction, taking into account the indexation provided for in paragraph 2 of Article 8-1 of this Law;

2) to consumers at contractual prices according to concluded bilateral agreements in accordance with the requirements of the legislation of the Republic of Kazakhstan on the electric power industry."

The first example of the implementation of a corporate PPA contract is the hybrid project of NC KazMunayGas JSC and the Italian Energy Company Eni S.p.A. (Eni).

The hybrid project involves combined generation of electric power from renewable energy sources (wind and solar) developed by the subsidiary Eni Plenitude, as well as a gas-fired power plant to balance and stabilize electric power production using Eni's international industrial experience.

The capacity of the solar power plant will be 50 MW, wind power plant – 77 MW and gas power plant – 120 MW. The hybrid power plant will provide stable and reliable electricity supply to KMG subsidiaries in the region, including Ozenmunaygas JSC and KazGPP LLP. This will eliminate the risks of emergency shutdowns in production due to frequent power outages.

In order to implement the project of NC KazMunayGas JSC, the Ministry of Energy of the Republic of Kazakhstan has developed Rules for the formation and management of hybrid groups for the regulatory and legal consolidation of the relationship between the project participants: the RES producing organization, the administrator of the hybrid group and consumers of the hybrid group, as well as with the balancing electric power market. Thus, according to the definition, a hybrid group is a group of subjects of the wholesale electric power market with a combined share of the use of renewable energy sources in the production of electric power of at least twenty-five percent located in one energy hub and included in the list of hybrid groups in accordance with the procedure approved by the authorized body. The administrator of a hybrid group is a legal entity belonging to a hybrid group that acquires (purchases) electric power from energy-producing organizations belonging to the hybrid group for the purpose of its subsequent sale to consumers within this hybrid group and(or) on the balancing electric power market, as well as being a balance provider for energy-producing organizations and consumers of electric power included in the hybrid group. A consumer of a hybrid group is a consumer who is a subject of the wholesale electric power market and is included in the list of hybrid groups.

[2] Renewables 2024. Analysis and forecast until 2030, International Energy Agency, 2024
[3] https://www.europarl.europa.eu/

In addition, in accordance with the legislation of the Republic of Kazakhstan, one of the mechanisms for supporting the implementation of RES projects is the so-called "qualified consumer".

The qualified consumers (hereinafter referred to as QC) is an entity or a group of entities that includes energy-producing organizations that use fossil fuels for the production of electric power, and (or) energy-producing organizations that own or legally own existing (commissioned after January 1, 2018 and not included by the authorized body in the list of energy-producing organizations using renewable energy sources) facilities for the use of renewable energy sources and(or) operating (commissioned after January 1, 2021) facilities for the use of secondary energy resources, which generated electric power is fully consumed by this entity or group of entities or sold to a single buyer of electric power at centralized auctions.

Historically, the Qualified Consumer mechanism assumed that such organizations pay monthly to the SFC for the amount of electric power proportional to the share of their own electric power supply to the grid, with a reduction from the RES volume in this QC and distribute electric power to end users, taking into account the costs in the selling tariff through a pass-through surcharge.

According to this mechanism, in 2022, as part of the strategy of the Fuel and energy complex of Kazakhmys Holding LLP, the 1st stage of construction of the Balkhash 50 MW SPP station was implemented. Kazakhmys Group is a vertically integrated holding with key assets concentrated in the mining industry and non-ferrous metallurgy. Kazakhmys ranks 20th in the world in the production of copper in concentrate (271 thousand tons) and 12th in the production of rough and cathode copper (377 and 365 thousand tons, respectively, taking into account the customer-supplied raw materials).

In 2020, the contribution of the Kazakhmys Group allowed the Republic of Kazakhstan to take the 11th place in the world ranking of silver-producing countries (279 tons, 51% of the total production in the country).

Kazakhmys Energy LLP includes two stations – Zhezkazgan TPP and Balkhash TPP, thereby providing the production facilities of Kazakhmys Corporation and the population of the cities of Zhezkazgan, Satpayev, Balkhash, and other areas with heat and electric power.

The SPP Balkhash occupies 140 hectares of land, of which 70 hectares of land are equipped. The remaining 70 hectares of land have been prepared for the construction of the 2nd stage of 50 MW. In the volume of stage 1, 94,150 double-sided photovoltaic modules, 8 inverter and transformer stations, each with a capacity of 6250 kV, a 220/20 kV substation, a 220 kV overhead line with a length of 2.5 km, were installed to generate a capacity of 50 MW, and the existing 220/110/10 kV Konyrat substation, owned by Kazakhmys Distribution LLP, was expanded." The 50 MW solar power plant is designed to generate over 80 million kWh of electric power per year.

However, as a result of the market reform and the introduction of a Single Buyer mechanism from July 1, 2023, the qualified consumer mechanism requires further improvement in the legislative framework.

Another industrial-scale RES project for the company's own needs, which is being implemented outside of auctions, is the solar power plant project of Solidcore Resources Plc. The project provides for the construction of 2 solar power plants with a total installed capacity of 39.6 MW in Abay and Kostanay regions within five years. As a regulating capacity, it is planned to build one gas piston maneuvering station with an installed capacity of 40 MW to cover the unstable generation of solar stations. The total investment will amount to more than $90 million.

It should be noted that today there are a number of significant barriers affecting the further development of the market for bilateral corporate RES contracts.

First. Inability to sell the RES electric power to retail consumers under bilateral contracts.

After the introduction of the new "Single Buyer" mechanism, the RES producing organization (in this example, a small hydroelectric power plant) cannot be a supplier of electric power to retail market entities. It must be a power supply company. In this regard, the RES plants need to conclude bilateral contracts for the sale of electric power with subjects of the wholesale electric power market.

In particular, a number of small hydroelectric power plants: Tasotkelskaya HPP 1, Tasotkelskaya HPP 2 (Kompaniya A&T Energo LLP); Karakystakskaya HPP (Zhambylskiye GES LLP); Merke HPP 1, Merke HPP 2 (GidroEnergeticheskaya kompaniya LLP); Merke HPP 3 (RemKommStroi LLP); Uspenovskaya HPP (Kainar-AKB LLP); Antonovskaya HPP (Cascade Karatalskikh GES LLP); Aksu HPP LLP; Sarkandskaya HPP (Firma Tamerlan LLP); 3 stations - Darkhan, Ryszhan, Koshkarata (Kelesgidrostroy LLP); Korday WPP (Izen Su LLP")

after the introduction of a Single Buyer, were unable to continue fulfilling their obligations to supply electric power to retail consumers (population, sanatoriums, recreation centers, farms, etc.) located in remote, hard-to-reach places.

Thanks to the amendments adopted in June 2024, a norm was fixed that obliges PSOs to purchase electricity from small hydroelectric power plants as a matter of priority. In particular, energy supply organizations, as a matter of priority, purchase electric power from hydroelectric power plants with a total installed capacity of no more than 10 megawatts located in their service area, commissioned before July 1, 2023 and which, as of July 1, 2023, did not have long-term contracts for the purchase and sale of electric power concluded with a single buyer in accordance with the legislation of the Republic of Kazakhstan in the field of support for the use of renewable energy sources, at the marginal tariff for electric power. At the same time, the purchase of electric power from these hydroelectric power plants is allowed at the level of installed capacity as of July 1, 2023.

Second. The requirements of the system operator for the availability of balancing capacities in the framework of the implementation of bilateral contracts..

In accordance with the electrical grid regulations (paragraph 4, Chapter 2), the scheme of power output of a power plant is coordinated with the system operator - the relevant organization (energy transmission or energy production), to whose electric networks it is planned to connect.

At the same time, the system operator will coordinate the power output scheme only if there are control capacities. Thus, if the project is intended to be implemented under bilateral agreements, without support through RFC LLP, a necessary condition for the implementation of this project (given the shortage of regulatory capacity in the UES of Kazakhstan, as a result of which an increase in the share of unstable RES facilities poses a threat to reduce the reliability of the UES of Kazakhstan) is the provision of regulatory capacity from the project applicant with connection to ALFC and the conclusion of a corresponding agreement with KEGOC JSC for the provision of electric power regulation services in the UES of Kazakhstan (the draft agreement is attached). At the same time, maneuverable generating capacities that are not currently involved in the power balance of the UES of Kazakhstan should be presented as an adjustment capacity. **As an alternative, it is possible to consider equipping the SPP with an energy storage device with a capacity of 50% of the installed capacity of the SPP and a capacity sufficient to deliver the installed capacity of the storage device within four hours.**

In this regard, the examples of renewable energy projects mentioned above are NC KazMunayGas JSC and Solidcore Resources Plc have decided to use gas generation as a balancing capacity.

It should be noted that currently there are no examples in the country of the use of BESS systems implemented in conjunction with RES projects in order to participate in the regulation of imbalances. The reason for this is the lack of operational experience of such systems, high capital costs for implementation and operational costs associated with the degradation of BESS and the need to maintain capacity.

The third. The lack of a regulatory framework for the development of the corporate PPA contracts segment.

One of the tools for the development of the RES market is the segment of corporate PPA contracts, when industrial enterprises conclude a direct contract with a RES generator for the purchase of "green" electric power in order to reduce their carbon footprint. Already today, as part of the implementation of the strategy to achieve carbon neutrality, most companies in the industrial sector have adopted strategies at the corporate level aimed at decarbonization of production processes. However, due to the lack of regulation of the corporate PPA contracts segment and the need to develop appropriate bylaws, the existing provision of the RES Law remains inactive, which leads to the fact that the development of corporate contracts for the purchase and sale of the RES electric power is not developing properly.

In order to avoid such a scenario, as well as achieve strategic goals on carbon neutrality, it is necessary to provide for a flexible approach to the development of renewable energy sources in the country by working with the Government of the Republic of Kazakhstan and the RES market to develop and approve Rules for the implementation of corporate RES PPA contracts.

Diagram X - Comparison of schemes for the implementation of the RES projects

	The RES having PPAs with RFC on RES LLP	Bilateral RES contracts
Rules governing the development of the RES market segment	The norms are fixed in the legislation and the RLA on RES	Missing
Exemption from payment for electric power transportation	Available	Missing
Priority dispatching	Available	Missing
Terms of the legislation on PPA	Guaranteed purchase of electricity for 20 years	has no right to switch to the sale of produced electric power by RFC on RES LLP
ES requirements for the availability of regulated capacity	Missing	Construction of an adjustment capacity or the use of storage devices
Real-time participation in the BEM	NPAs developed	No working conditions

Source: Qazaq Green RES Association

Fourth. It is necessary to improve the mechanism of qualified consumer

Thus, companies implementing the RES projects through the QC mechanism note the following problems.

Firstly, after the introduction of a Single Buyer, conceptual discrepancies arose in the legislation. Thus, in accordance with Article 165 of the Entrepreneurial Code of the Republic of Kazakhstan, energy-producing organizations using renewable energy sources and operating within the framework of the QC are defined as a group of persons. At the same time, in accordance with Article 15-5 of the Law of the Republic of Kazakhstan "On Electric Power Industry", a group of entities is included by the authorized body in the Register of Groups of Entities for the creation of electric power capacity. However, for example, there are cases when a group of individuals from the register of energy-producing organizations using traditional fuels that are part of a qualified consumer. Thus, from the point of view of the conceptual framework of the Law of the Republic of Kazakhstan "On Electric Power Industry", such projects cease to meet the criteria for classification as qualified consumers, although in accordance with the Entrepreneurial Code of the Republic of Kazakhstan they are, since they meet the criteria for classification as a “group of entities”. Thus, the exclusion from the Register of a group of entities responsible for creating electric power under the Law of the Republic of Kazakhstan "On Electric Power Industry" should not be a criterion for excluding a group of persons from the qualified consumer mechanism.

Secondly, the consumer in the QC mechanism actually has to buy electric power from both a Single Buyer and an EPO for RES, which is part of the same group of entities with it. Taking into account that there is a share of the RES electric power in the electric power purchased from a Single Buyer, it turns out that the consumer purchases a "double" volume of the RES electric power in the purchase mechanism, which is currently not balanced.

Based on the above, we believe that due to the fact that legislative acts provide for the possibility of selling electric power within a group of persons, the accompanying legislative acts should be brought into full compliance in order to eliminate further discrepancies and form a "solid" regulatory framework for the implementation of RES projects through the mechanism of qualified consumers.

For this purpose, the following steps are necessary:

1. Consider the norms in legislation under which consumers, as part of a group of persons, could purchase electric power from both a Single Buyer and an EPO for RES on the principle of a qualified consumer and reduce the cost of RES from a Single buyer by purchasing such electric power from an EPO for RES included in the same a group of entities.

2. Consider introducing a mechanism for recalculating (balancing) electricity purchases for those organizations that have implemented renewable energy projects using the qualified consumer mechanism / redistributing cost shares to support the use of renewable energy sources to consumers in a group of entities.

3. To bring into line the concepts of "groups of entities" (the Business Code of the Republic of Kazakhstan), "register of groups of persons" (the Law of the Republic of Kazakhstan "On Electric Power Industry"), "qualified conditional consumer" (Rules for the formation of a plan for the placement of facilities for the use of renewable energy sources) in the regulatory framework.

Thus, the development of the corporate PPA contract sector can not only contribute to the development of RES in the country, but also work to increase the competitiveness of enterprises and reduce the carbon footprint.

QAZAQ GREEN

III International business festival on renewable energy sources

QAZAQ GREEN FEST 2024

ACCEPTING THE CHALLENGES OF THE PRESENT – TOGETHER TOWARDS A SUSTAINABLE FUTURE


NABI AITZHANOV
GULZHAN NALIBAYEVA
SUNGAT YESSIMKHANOV

IMPLEMENTATION OF RENEWABLE ENERGY

I. Participation in the auction

1. Check the auction schedule

Order of the Minister of Energy of the Republic of Kazakhstan No. 202 of May 21, 2020 "On approval of the auction schedule for 2020"

2. Register at the website of KOREM JSC, conclude an agreement and undergo a training on the use of the trading system

- title documents *
- documents on the land plot
- documents on the connection point

* Foreign legal entities shall provide the equivalent documents with notarized translations of each document into the Kazakh and Russian languages

3. Financial guarantee for auction participation

- for auctions without documentation - 2000 KZT per 1 kW of installed capacity
- for auctions with documentation - 5000 KZT per 1 kW of installed capacity

4. Auction participation

- FSC provides envelopes with financial guarantee
- observers gather in the hall
- 30 minutes before the auction, the envelope is opened, and the data is entered into the system
- trading session opens (accepting and changing bids)
- trading session closes, auction results

5. Auction results

- auction winners
- auction prices
- volumes of selected capacity

II. Post-auction activities and project implementation

1. Inclusion in the RE Facilities Siting Plan and the List of Energy Producing Organizations Using RES

The Ministry of Energy of the Republic of Kazakhstan shall include the winners in the RE Facilities Siting Plan and the List of Energy Producing Organizations Using RES within 5 working days from the date of receipt of the Register of winners from the organizer

2. PPA conclusion

The winner submits an application for the conclusion of the PPA to the FSC within 60 calendar days from the date of inclusion in the List of Energy Producing Organizations using RES

3. PPA financial guarantee

The amount of financial guarantee of the fulfillment of the terms of the purchase agreement is 10,000 (ten thousand) KZT per 1 (one) kW of installed capacity

4. Project implementation terms (from the date of PPA conclusion)

- for SPP - 24 months
- for WPP and BioPP - 36 months
- for HPP- 48 months

5. Registration of land rights, design and survey works

- land plot selection
- obtaining the permit to use the land plot for design and survey works
- design and survey works (D&S)
- obtaining the land plot rights
- obtaining the water use rights (for HPP)

More information: USAID, Investor's Guide to Renewable Energy Projects in Kazakhstan, 2022

PROJECTS IN KAZAKHSTAN

QAZAQ GREEN Association

6. Grid connection

- request to identify the closest connection point to the energy transmitting organization
- development of power generation scheme
- obtaining technical specifications for a connection to the electric grid
- approval of the power generation scheme by the system operator
- conclusion of an agreement on RE facility connection

7. Preliminary project procedures and design

- obtaining source materials to develop construction projects
- approval of schematic design with the construction authority
- development of project documentation (Feasibility study, Design and estimate documentation), approval, expert examination of DED by a design institute (state or private)
- installation and construction works

8. Environmental Permit

- environmental impact assessment (Ministry of Ecology)
- environmental emissions permit (egov.kz)

9. Investment preferences under Entrepreneurial Code

10. State registration of the right to a constructed renewable energy facility

- inclusion of identification and technical information on newly created immovable property in the information system of the legal cadastre (egov.kz)

III. Commissioning *

** SPP as an example*

1. The contractor notifies the customer of the facility's readiness for commissioning

2. The customer asks to provide (within 3 days):

- contractor -declaration of compliance
- technical and designer supervision - conclusion on the quality of the works performed
- technical supervisor- conclusion on the quality of the completed construction and installation works

3. Substation commissioning

Grid connection:

- Acceptance in Commercial Operation of Automated Commercial Energy Metering System (ACEMS) and registration in the ACEMS register
- signing contracts for system services with SO and REC
- compliance with technical conditions for grid connection
- notification of FSC about carrying out complex tests in set period
- successful completion of complex tests
- connecting the substation to the grid

Substation commissioning:

- signing of the commissioning act by the customer, general contractor, authorized technical supervisor
- registration of the act with the justice authorities
- registration of rights to immovable property
- creation of a facility's technical passport
- sending documents to FSC in the set period

4. Solar park commissioning

- signing of the commissioning act by the customer, general contractor, authorized technical supervisor
- registration of the act with the justice authorities
- registration of rights to immovable property
- creation of a facility's technical passport
- sending documents to FSC in the set period

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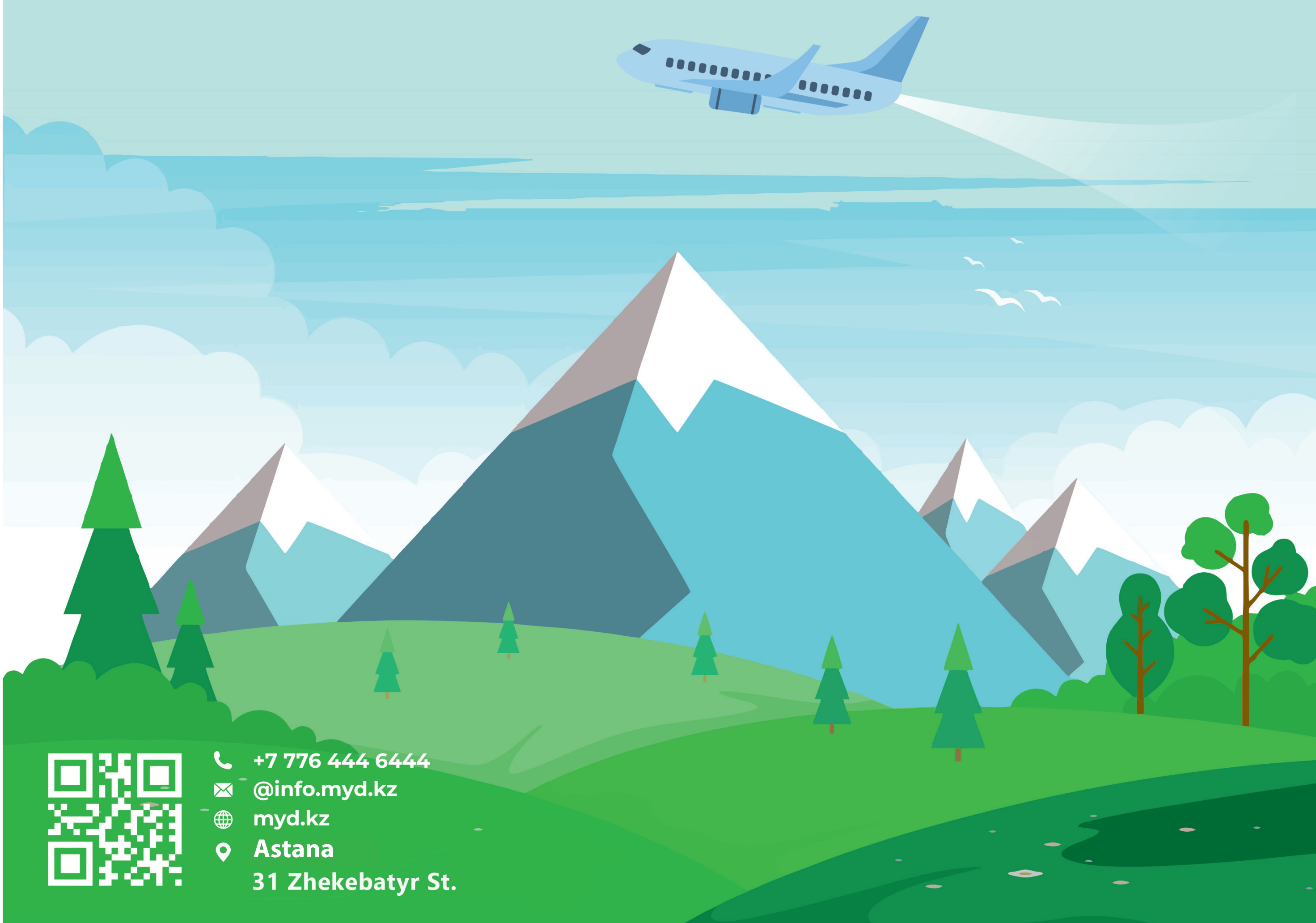

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PLATFORM FOR NATIONAL AND INTERNATIONAL PLAYERS IN RENEWABLE ENERGY SOURCES

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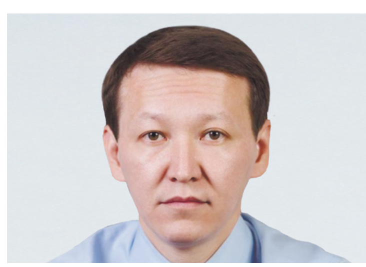

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ASSOCIATION AS INFORMATIONAL RESOURCE

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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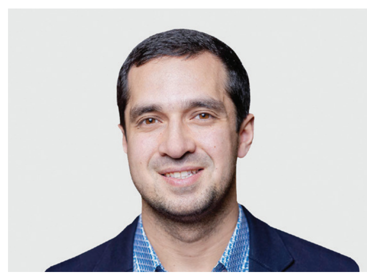
Member of the Board



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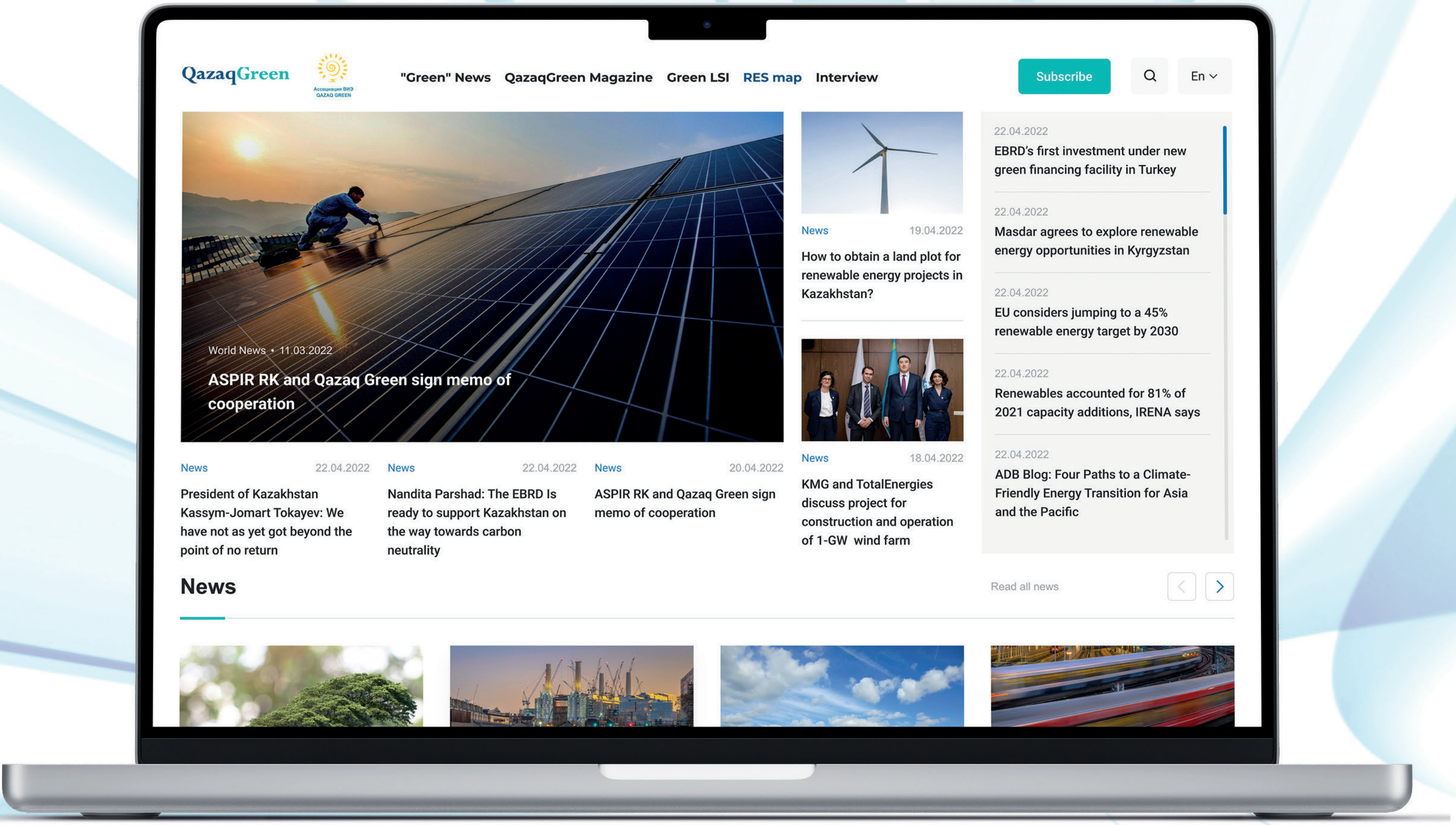

Qazaq Green has launched information portal on "green" economy of Kazakhstan

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.

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- **Policy and Party Counselling**
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