



Eurasian
Development Bank

POWER SECTOR OF CENTRAL ASIA:

Modernization and Energy Transition



Report 26/4

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POWER SECTOR OF CENTRAL ASIA: MODERNIZATION AND ENERGY TRANSITION

KEY FINDINGS

ANALYTICAL REPORT 26

THE GLOBAL ENERGY SECTOR IS UNDERGOING ITS MOST SIGNIFICANT TRANSFORMATION SINCE THE INDUSTRIAL REVOLUTION

Share of renewable energy in global generation in 1H 2025

34.3%

(exceeding coal's share of 33.2% for the first time)

New challenges for the global energy sector

- Integration of hundreds of GW of variable renewable energy sources
- Electrification of industries (30% of the energy balance by 2040)

20%

today

30%

by 2040

A solution for economic policy



THE ENERGY TRILEMMA

Balance between sustainability, reliability, and affordability of energy

THE REGION FACES GROWING DEMAND, ASSET DEPRECIATION, AND THE NEED FOR DECARBONIZATION AND INTEGRATION OF RENEWABLE ENERGY SOURCES



+40%

Demand growth by 2030 (from 270 to 370 TWh)



up to

70%

Infrastructure degradation

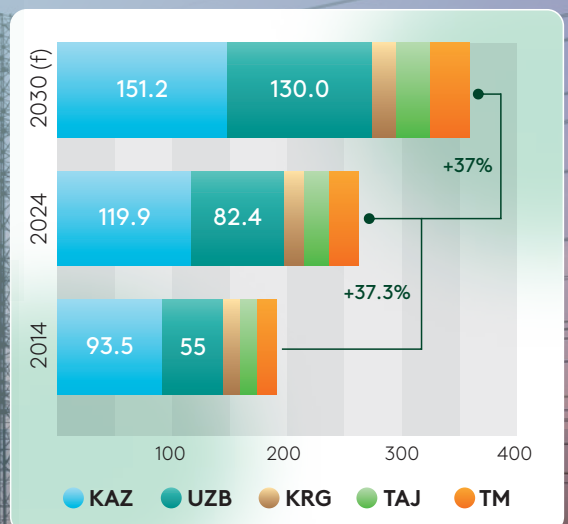


1.4

trillion USD

Investment needed in the region for Net Zero by 2050

Electricity demand in Central Asia by 2030, TWh



THE "MIDDLE" PATH — A BALANCED AND PRAGMATIC APPROACH TO ENERGY TRANSITION

Generation

- Modernization of existing assets
- Flexible generation: CCGT, GTU, BESS, and PSP
- Low-carbon development: nuclear power plants, RE
- Decentralized generation

Grids

- Grid upgrades
- Digitalization: SCADA/EMS
- Smart sensors and meters

Market

- Elimination of cross-subsidies
- Development of ancillary services market
- Transparent rules for grid access and PPAs

Consumption

- Dynamic tariffs
- Energy efficiency in industrial and residential sectors
- 'Smart' load management

Integration

- Joint reserves and coordination of regulation
- Regional electricity market
- Joint network planning
- Seasonal complementarity of generation

Transition

- Staff retraining and job protection
- Diversification of company towns



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Full version of the analytical report



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The report analyzes the transformation of Central Asia’s energy sector and proposes a “middle path” strategy. It is based on the World Energy Council’s energy trilemma concept – the balance among security, affordability, and environmental sustainability. Against the backdrop of the global energy transition, with a record 585 GW of green capacity installed worldwide in 2024, Central Asia is facing rapid growth in electricity demand (*up to +40% by 2030*), high wear and tear on infrastructure (*up to 70% of networks and thermal power plants*) and dependence on coal and gas. At the same time, the region has enormous potential for the development of RE sources – solar, wind and hydro power – as well as opportunities for the introduction of nuclear and gas hybrid capacities. The proposed “middle path” strategy is based on a pragmatic combination of modernizing traditional generation, phased development of RE sources, introduction of energy storage systems and digitalization, as well as restoration of regional integration of energy systems to balance seasonal and resource differences. This approach will enable Central Asian countries to ensure reliable and affordable energy supplies, reduce their carbon footprint, strengthen energy security, and lay the foundation for sustainable economic growth in the 21st century.

Keywords: Central Asia, electric power industry, RE, energy transition, water-energy balance, sustainable development, “middle path”.

JEL: C10, E17, L81, L91, R33, R42.

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INTRODUCTORY NOTE BY THE EURASIAN DEVELOPMENT BANK'S CHAIRMAN



Nikolai Podguzov,
Chairman of the EDB
Management Board

The global energy sector is entering a new phase — the most significant transformation since the Industrial Revolution. In 2024, renewable energy sources accounted for 92% of all new power generation capacity worldwide, and their share in global electricity generation exceeded that of coal-fired power plants for the first time. However, global greenhouse gas emissions rose to record levels, showing that technological progress alone does not guarantee sustainability. The world is facing a new dilemma: how to ensure reliability, affordability, and environmental sustainability at the same time.

In these conditions, the energy trilemma — the balance between security, affordability, and environmental sustainability — becomes the central focus. For all countries, regardless of their level of development, the key question today is not only “how quickly to transition to clean energy,” but also “how to make this transition sustainable and fair.” The “middle way” concept presented in this report offers just such an approach: a pragmatic combination of modernizing traditional generation, gradually increasing renewable energy sources, digitalization, and developing energy storage systems.

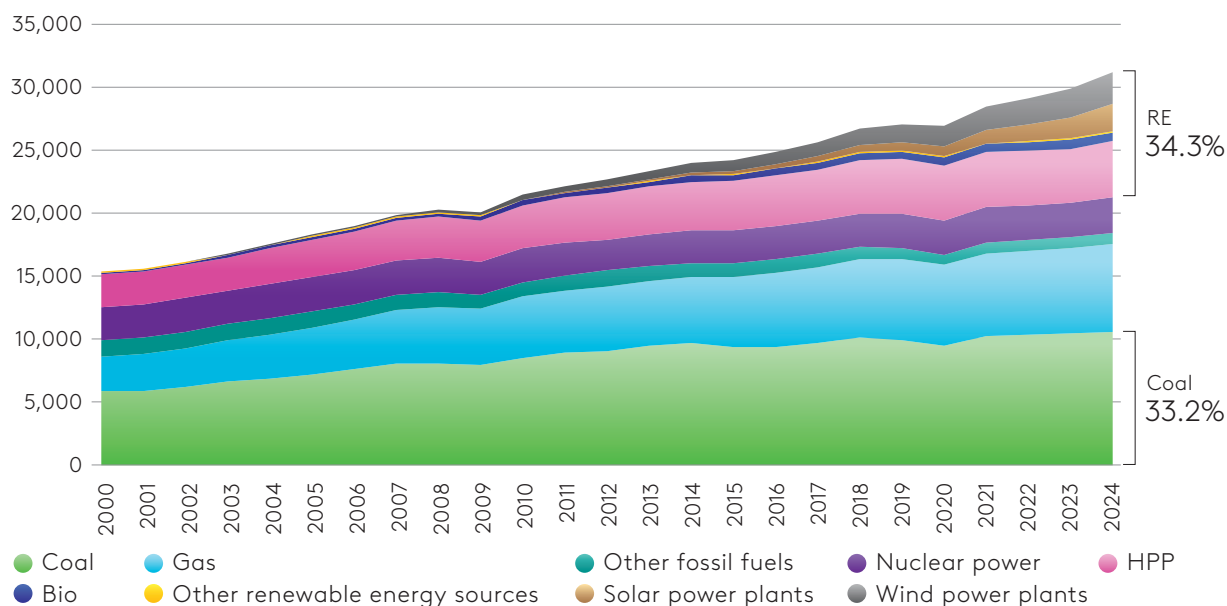
Central Asia is a region where the challenges and opportunities of the energy transition are particularly acute. Here, total demand for electricity could grow by 40% by 2030, while up to 70% of grids and thermal power plants are in need of modernization. At the same time, the region has unique resources: the largest hydropower potential, vast areas for solar and wind generation, significant gas reserves, and a strategic location between Russia, China, and South Asia. Strengthening regional integration plays a special role. Expanding cross-border ties and sharing water and energy resources can reduce systemic risks, balance seasonal differences, and attract large-scale private investment.

At the same time, a successful energy transition will require protecting vulnerable populations, maintaining affordable tariffs, and supporting employment in traditional industries. In this sense, Central Asia can offer a universal example for other regions of the world: a transition based on a balance of interests, capable of combining climate goals with the objectives of economic development, energy security, and justice.

SUMMARY

The global energy sector is undergoing **its most significant transformation since the Industrial Revolution**. Over the past decade, key clean technologies have reached scales that were previously considered unattainable: a record 585 GW of renewable energy capacity had been installed in 2024. For the first time in history, the share of renewable energy in global electricity generation — 34.3% — has exceeded that of coal (33.2%). This is largely due to the fact that renewable energy has become highly competitive with other generation technologies in terms of cost: since 2015, the levelized cost of electricity (LCOE) from utility-scale solar plants has fallen by 70%, and from wind power plant by 55%. Investments in the energy transition reached \$2.2 trillion, twice the amount invested in fossil fuels.

↓ Figure A. Global electricity generation mix, billion kWh



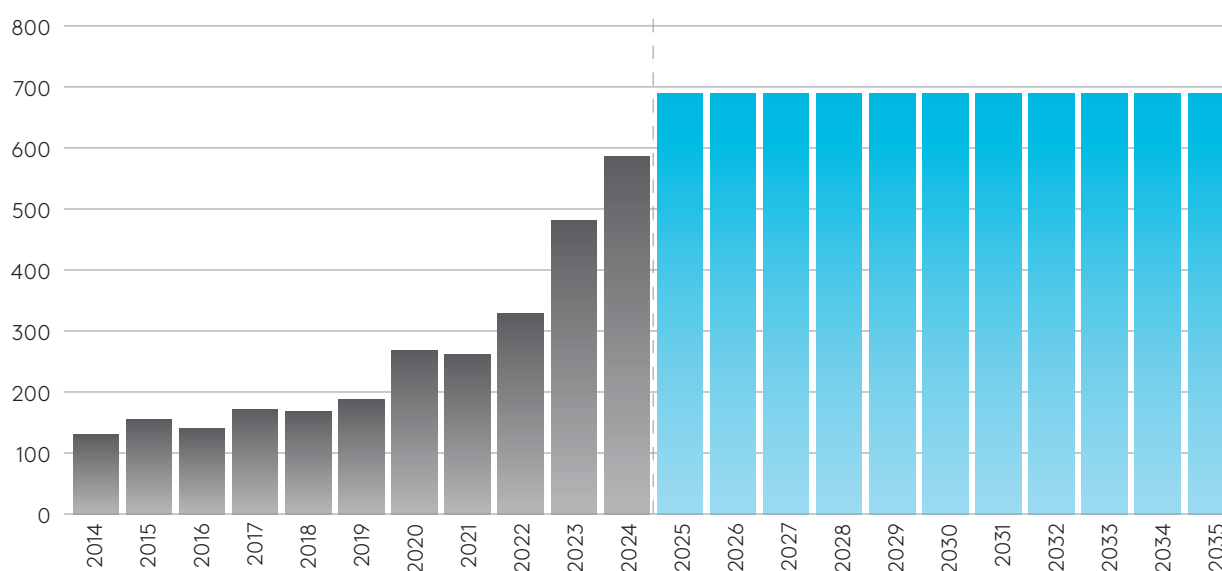
Source: Ember, 2025.

However, these achievements are accompanied by new challenges. **The electricity demand growth is outpacing the ability to integrate** new low-carbon technologies, so global CO₂ emissions rose again in 2024, reaching record levels. Hundreds of GW of RE objects are in queue for connection. The main constraints are technical in nature. If the drop in power output caused by weather changes is not immediately compensated for, the systems may be at risk of blackout. Power systems need to adapt to significant amounts of electricity from solar power plants in the middle of the day, which requires a ramp-down from other generators during the day and a steep ramp-up in the evening. Variable generation is being introduced faster than grids, storage systems, flexible reserve capacity, and operational management tools can develop. **Infrastructure in many countries is not designed for a high share of variable generation**, while weather forecasting accuracy remains insufficient to maintain an acceptable level of system reliability. Reforms of capacity, reserve,

and tariff regulation markets in many countries are also lagging behind, which does not encourage the creation of the necessary support mechanisms. As a result, the real cost of renewable energy is higher than expected, and the risks to energy supply reliability are increasing.

At the same time, **electricity is becoming the central form of energy** in the global economy amid digitalization and the rapid expansion of artificial intelligence applications. The share of electricity in final energy consumption will increase from 20% today to 30% by 2040 as the electrification of industry, transport, and heating accelerates. Additional demand is growing: according to IEA estimates, investment in data centers will reach 580 billion USD in 2025. Electricity consumption by data centers could triple by 2035. In this scenario, the reliability of electricity supply comes to the forefront. New demand (*AI, data centers, digital services, electrified supply chains*) requires firm power and system stability, which can only be provided by dispatchable and stable sources along with upgraded grids and sufficient reserves.

↓ Figure B. Estimate of average renewable energy additions up to 2035, GW



Source: IEA, 2025a.

The global energy transition has now entered a new phase, where **system reliability and balance are becoming key issues**. Having achieved lower prices for green technologies, the global community is now faced with the challenge of integrating rapidly growing volumes of variable generation into engineering and infrastructure solutions — the development of networks, energy storage systems, flexible capacity, and digital management platforms — will determine whether low-carbon energy can be scaled up effectively. In this context, **the concept of the energy trilemma** — the balance between environmental sustainability, security of supply, and energy affordability — **comes to the fore as a key policy principle**. A unilateral pursuit of only clean energy goals without considering energy security and equity leads to vulnerability.

This is particularly evident in Central Asia, which fits into the global context with its own specific characteristics. **The region, with a population of over 80 million, is showing steady growth in electricity demand** of 3–6% per year, and by 2030, consumption could grow by another 40% or so — from the current 270 billion to 370 billion kWh per year. The energy infrastructure is worn out: in some countries, up to 70% of power grids and thermal power plants have reached the end of their service life, and on average across the region, more than 60% of distribution networks require replacement or major repairs. Transmission and distribution losses reach 15–20%, which is 2–3 times higher than in developed countries. Many of the existing power plants were built during the Soviet era and have long since recouped their capital costs, which is why they now provide the cheapest electricity — their wholesale price can be several times lower than that of new facilities. This temporarily keeps tariffs down, but at the same time masks the problem: a significant portion of generating assets have reached the end of their useful life, accidents are on the rise, and their imminent replacement will inevitably lead to higher energy prices.

The structural vulnerability of Central Asia’s energy sector complicates the energy transition. The region’s energy mix is not diversified: Kyrgyzstan and Tajikistan are almost entirely dependent on hydropower (*up to 90% of generation*), while Kazakhstan, Uzbekistan, and Turkmenistan rely on fossil fuels (*coal and gas provide the basis for generation*). Hydropower generation drops sharply in winter, leading to acute electricity shortages: hydro-dependent systems are prone to rolling blackouts and energy imports. In gas-dependent power systems, cold periods lead to consumption spikes and pressure drops in the gas network that affect power plant operations. The region also suffers from low energy efficiency, high specific fuel consumption at outdated thermal power plants, limited interconnectivity of energy systems, a lack of flexible capacity, and a low level of digitalization. The instability of water resources due to melting glaciers and the increasing frequency of extreme weather events (*frosts, droughts*) further exacerbate the situation. These factors underscore that the energy transition in Central Asia requires a systematic and pragmatic approach adapted to regional specifics.

Nevertheless, the region also has **unique opportunities for balanced development.** Central Asia has enormous renewable energy potential — rich resources of sun, wind, and hydropower — as well as significant natural gas reserves and uranium for nuclear power generation. The combination of serious challenges and rich resources dictates the need for a “middle path” strategy based on balancing the goals of the energy trilemma: reliability, affordability and sustainability. Extreme approaches — whether a forced abandonment of fossil fuel generation or, conversely, the zealous ‘lock-in’ to existing outdated infrastructure — carry unacceptable risks. The optimal scenario appears to be an evolutionary one, in which countries in the region modernize their existing energy sector, making the most of their current infrastructure, while simultaneously laying the foundations for a future low-carbon system. This pragmatic course will ensure energy security and affordability today without sacrificing sustainability tomorrow.



CONSERVATIVE SKEPTICISM

“Renewables are a scam”

- Focus on conventional generation (coal, gas)
- Priority — energy security (*including dependence on imported equipment and critical metals*)
- Fuel/electricity price stability
- Fossil fuels as the basis of the energy mix
- Climate goals are secondary
- Rejection of new technologies (electric vehicles, hydrogen, renewable energy sources)



“THE MIDDLE PATH”

Balance

- Combination of conventional (baseload) and variable (renewable energy sources) generation
- Modernization of existing thermal power plants and gradual phase-out
- Development of renewable energy sources with energy storage systems
- Recognition of the role of gas
- Development of nuclear energy
- A just transition for affected industries



GREEN MAXIMALISM

“Renewables are a panacea”

- Rapid decarbonization, even at the cost of short-term economic losses
- Complete phase-out of coal and ICE by 2040
- Large-scale expansion of renewable energy sources and full electrification
- Renewables should provide up to 90–100% of electricity
- Strict regulation of emissions, carbon tax, and elimination of subsidies for fossil fuels

First, **existing assets** need **to be modernized** where it makes economic sense. These assets currently provide the lowest cost of electricity for economic development and are often the only source of heat supply in severe climate of the region. It is critical to extend the life of existing coal, gas, and hydroelectric power plants by increasing both their efficiency and flexibility for future purposes, where possible. Upgrading equipment can reduce specific fuel consumption, cut emissions, and extend the service life of power plants by 10–15 years. At the same time, it is important to upgrade the grid infrastructure, reducing losses and introducing digital control and monitoring tools. Infrastructure can the growing volumes of renewable energy sources be safely integrated.

Secondly, **it is advisable to increase the flexibility of the region’s energy systems.** The expansion of variable solar and wind generation must be accompanied by the creation of rapid response reserve capacity. It is necessary to build modern gas turbines that can be quickly activated when RES generation drops, as well as to introduce energy storage systems. Demand response mechanisms should be developed, both in industrial and residential sectors. Hybrid energy parks, which combine renewable energy sources, gas installations, and storage facilities on a single site for round-the-clock energy supply, are a promising solution. Without sufficient flexibility, a high share of renewable generation will lead to an increased risk of outages and accidents.

Thirdly, **tariff and market reforms** are important. The transition to economically feasible retail tariffs will eliminate chronic underfunding of the industry and create predictable conditions for private investment. Of course, tariff increases should be gradual and accompanied by targeted social support — subsidies for vulnerable groups instead of universal benefits. This will preserve energy accessibility for citizens without depriving energy companies of resources for modernization. It makes sense to update the electricity market design. Historically, the region has operated a model of trading only energy (*kilowatt-hours*) at fixed prices, which does not reflect the realities of the new era. As the share of renewable energy sources grows and demand patterns becomes more complex, it is becoming important to launch markets for capacity, reserves, and ancillary services. The capability of a power plant to provide power on demand, even if it is idle most of the time, is valuable for modern systems. Compensation for grid stability services (*supplying reserve capacity, frequency regulation, rapid recovery after accidents*) will create incentives for the construction of flexible gas units, large energy storage facilities, and fast-response generating units. The formation of fully-fledged wholesale and balancing markets, based on the experience of other regions, will increase transparency and reliability.

Fourth, **it is important to efficiently integrate renewable energy sources into the grid**. It is not enough to simply build hundreds of megawatts of solar and wind power plants — it is important to integrate them into the power grid in advance, taking into account the maximum capacity and future bottlenecks. New renewable energy plants should be located where the grid can accept additional capacity without loss of quality. It makes sense to build power lines to promising sites in advance. Another important element is the installation of energy storage systems at renewable energy parks to smooth out fluctuations in power output. At the same time, modern means of forecasting generation and load can be introduced — improving the accuracy of forecasts will allow reserves to be used more economically. A comprehensive approach also implies **a fair transition** for the people and industries affected by the transformations.

Finally, **regional integration is a key element of the strategy**. Expansion of interconnector capacity and regional coordination can significantly increase the resilience of Central Asia's energy systems.. The joint development of large projects — such as hydroelectric power plants or GW-scale wind farms designed to export electricity to neighbors — will give all participants access to cheap and clean sources. Coordination of water and energy regimes will allow for optimal use of hydropower potential without disrupting irrigation regimes. The creation of regional power and electricity markets will have economies of scale: countries will be able to share reserve generators. For investors, an integrated market with more than 80 million consumers is also much more attractive than fragmented ones. The experience of other integrated power systems shows that interconnection strengthens all aspects of the trilemma at once: reliability is increased through mutual backup, tariff pressure is reduced through optimal load distribution, and the introduction of renewable energy sources is facilitated by the geographical dispersion of generation.

A high-level comparative assessment of three scenarios for the development of the Central Asian electricity sector indicates that it is the integrated “middle path” strategy that provides the most sustainable profile across the entire energy trilemma. Based on the plans of Central Asian countries as stated in their strategic reports, the expected total new power generation capacity amounts to at least 62.8 GW by 2035, equivalent to 230 billion kWh of new annual generation. Comparative modeling shows that this scenario entails CAPEX of approximately 151–179 billion USD, which is 30–45% lower than the “green maximalism” scenario (\$239–254 billion) and comparable to the conservative scenario (150–170 billion USD). In terms of normalized electricity generation costs, the “middle path” is also comparable to the conservative approach, ranging from 8.6 to 10.3 cents/kWh, which is 25–35% lower than “green maximalism” (11–12.2 cents/kWh), but is accompanied by a carbon footprint that is five times smaller. On a life-cycle basis, emissions amount to approximately 0.15 tonnes CO₂e/MWh versus 0.8 tons of CO₂e/MWh in the conservative scenario—that is, nearly five times lower—while maintaining high system stability.

A balanced “middle path” strategy provides Central Asia with a realistic roadmap to energy sector modernization. A set of measures — from extending the life of essential assets and increasing system flexibility to market reforms, proper integration of renewable energy sources, and a new phase of regional cooperation — will ensure reliable and affordable energy supply, significantly reduce its carbon footprint, and lay the foundation for sustainable economic growth in the 21st century.