

Energy Without Borders:

The Architecture of Power Connectivity in Central Asia



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ENERGY WITHOUT BORDERS

The Architecture of Power Connectivity in Central Asia

KEY TAKEAWAYS

ANALYTICAL REPORT '26

POTENTIAL IMPACT OF A DEVELOPED ARCHITECTURE



Up to **640**
USD million/year
gross effect



Up to **120**
USD million/year
net effect



2.8–4.5
billion kWh/year
lower RES curtailment

4 BENEFIT CHANNELS

Trade arbitrage

Shared reserves

Less RES curtailment

Lower emergency costs

CHALLENGES

Why existing interconnection is not fully used



GRID AT ITS LIMIT

102–123%

overloads on key lines at the 2024 peak

GRID



CAPACITY ≠ AVAILABILITY

6.6 GW

unavailable/restricted + 0.85 GW under repair

AVAILABILITY



RES OUTPACE THE SYSTEM

3.5 billion kWh

RE curtailment in Uzbekistan in 2028

FLEXIBILITY



POORLY CONTROLLABLE GRID

Outages 2022–2026

cascading trips ·
manual coordination · conservative limits

CONTROLLABILITY

ROOT CAUSES

Five structural constraints explain the four system-level challenges



GRID
BOTTLENECKS

- Both within countries and at interfaces
- Physical link ≠ available transfer capacity



GENERATION
AVAILABILITY

- 6.6 GW was unavailable at the 2024 peak for various reasons



FLEXIBILITY
& RESERVES

- Limited maneuverability of existing generation
- Shortage of fast-acting reserves and storage
- Limited joint use of reserves



OBSERVABILITY
& AUTOMATION

- Incomplete picture of grid state
- Fragmented data and models
- Manual coordination



INSTITUTIONS
& RULES

- Differing rules and areas of responsibility
- Immature balancing and ancillary services mechanisms
- Allocation of benefits and costs

SOLUTIONS

Three dimensions of integration



PHYSICAL

- Strengthening internal corridors and cross-border interfaces
- Development of BESS and flexible capacity
- Substations, transformers + reactive power compensation



TECHNOLOGICAL /
DIGITAL

- Unified digital loop: SCADA/EMS · AGC · WAMS/WACS · AMI · verified models
- Secure data exchange + settlement infrastructure
- Automatic control + emergency control
- RES and load forecasting + ATC/NTC calculation



INSTITUTIONAL

- Allocation of powers and functions among system operators, national regulators, CDC and market participants
- Launch of pilot markets: day-ahead, balancing, ancillary services
- Hydro-flexibility payment mechanism + allocation of benefits and costs

National dispatch control is retained; regional functions develop as integration matures.

PHYSICAL CONNECTIVITY + CONTROLLABILITY = REGIONAL SYSTEM EFFECT



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Full version of
the analytical
report



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Central Asia is not starting its energy integration from scratch: the region has inherited a well-developed grid interconnection, seasonal water-energy exchanges, and complementary resources. However, the previous architecture was designed for a different reality—current conditions require greater controllability of the power system. This report examines regional electricity cooperation and integration as a practical mechanism for a “Middle Path” strategy—that is, a balance between reliability, energy affordability, and environmental sustainability. The key argument is that the future value of an interconnected system will be determined not only by the scale of the infrastructure, but above all by the level of controllability, transparency, and the ability to ensure reliable regional coordination.

Experience from developed markets shows that the benefits of integration stem not only from electricity trade, but also from lower reserve costs, an expanded balancing zone, higher asset utilization, and lower curtailment of renewable energy. The report provides an analysis of the current situation and challenges, as well as a phased roadmap for increasing cross-border trade: from observability, metering, deviation rules, emergency support, and balancing energy exchange to short-term trading, balancing, the ancillary services market, and regional instruments for ensuring long-term resource adequacy. This phased approach will enhance the reliability of the Central Asia Power System, reduce the total cost of reliability, alleviate curtailment of RE, unlock the investment value of grid and digital projects, and prepare the region for sustainable participation in external power markets.

Keywords: Central Asia, Central Asia Power System (CAPS), “Middle Path,” energy trilemma, power sector, RE, energy transition, electricity trade, sustainable development, regional interconnectivity.

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SUMMARY

Central Asia already has a substantial degree of physical power-system interconnection, inherited from the Soviet-era grid. Its economic and system-wide value today is constrained less by nominal generating capacity than by operational controllability: data quality, settlement metering, secure information exchange, automatic controls, and clear rules for coordination and settlement. The central challenge is therefore to turn inherited physical interconnection into a transparent and manageable regional architecture.

Assessment of the Joint Power System

The Central Asia Power System (CAPS) is the regional synchronous power system linking Uzbekistan, Kyrgyzstan, Tajikistan, and southern Kazakhstan, while selected generating units in Turkmenistan and northeastern Afghanistan are connected through islanded configurations. As of January 1, 2025, installed capacity within the CAPS technical perimeter was 38.6 GW; in 2024, generation totaled 125.4 billion kWh and consumption 142.2 billion kWh. Regional trade recovered from 2.5 billion kWh in 2010 to 12.1 billion kWh in 2024, but remains below its 1990 level relative to consumption (about 8.5% versus 13%) and about half the EU level, because of grid constraints, reserve availability, and incomplete formalization of commercial arrangements.

The report's central diagnostic finding is that the region's central constraint is not installed capacity, but the availability, flexibility, and deliverability of capacity in critical hours. Fuel and hydrological constraints, offline thermal units, and grid bottlenecks mean that part of the nameplate capacity is unavailable precisely when the system needs it most. Regional cooperation therefore creates value only where resources are demonstrably available and deliverable, rather than merely present on paper.

The region's power systems contribute complementary resources to a common reliability portfolio. Uzbekistan is the largest center of demand, generation, and renewable integration; southern Kazakhstan is a major load center exposed to North–South transit constraints; Kyrgyzstan and Tajikistan provide hydropower flexibility and seasonal balancing; Turkmenistan can supply surplus gas-fired capacity under suitable interconnection arrangements; and Afghanistan remains a potential southern offtake and transit market.

Renewables Increase the Cost of Poor Coordination

Countries across the region are rapidly expanding solar and wind generation. In Uzbekistan, renewable capacity could reach 25 GW by 2030 under announced plans. At the same time, curtailment of renewable energy (RE) is projected to rise from about 2.2 billion kWh in 2026 to 3.5 billion kWh in 2028 under conservative assumptions. Curtailment reduces usable generation, while payment obligations to generators may remain, depending on PPA terms, leaving the associated costs with the offtaker, system operator, or ultimately consumers. Regional interconnections, access to hydropower flexibility, storage, and stronger market signals can materially reduce this burden.

Economic Benefits of Integration

The economic rationale for integration lies in reducing the total cost of reliable electricity supply through four channels: trade arbitrage, reserve sharing, lower curtailment of RE, and lower emergency costs. A preliminary scenario-based assessment indicates a net system-wide effect of about USD 120 million per year under both the partial and deeper integration scenarios and about USD 40 million per year under the advanced regional architecture in the central case (midpoint). These are annual values, not cumulative or lifetime amounts. Under unfavorable conditions, such as low utilization combined with high infrastructure costs, the net effect may be negative, particularly for the advanced regional architecture. The results point to diminishing marginal returns as integration deepens: partial integration captures relatively low-cost gains from improved use of existing infrastructure and coordination, while subsequent stages require progressively larger grid and institutional investments. This supports a phased approach in which deeper integration is pursued as earlier stages demonstrate sufficient utilization, system benefits, and institutional readiness. The estimates are screening-level indications of the order of magnitude of the potential effect rather than forecasts; outcomes may be materially higher or lower depending on infrastructure costs, utilization, and the effectiveness of regional coordination.

Regional benefits will not be distributed evenly. One country may benefit from lower curtailment of RE, another from transit revenues, a third from remuneration for hydropower flexibility, and a fourth from lower shortage or emergency-support costs. A project that is economically attractive for the region as a whole can therefore remain politically difficult unless benefit-sharing and cost-allocation mechanisms are defined in advance.

Hydropower as a Remunerated Resource for System Flexibility

Hydropower in Kyrgyzstan and Tajikistan, including Toktogul, the Naryn Cascade, Nurek, and the prospective Rogun HPP, provides peak support, balancing, reserves, and seasonal flexibility to the region. Water is a multipurpose resource linked to irrigation, food security, and interstate water obligations. Hydropower flexibility should therefore be treated as a measurable and remunerated ancillary service, not as a free reserve available to downstream systems by virtue of geography. A credible regional model must explicitly compensate this flexibility, while respecting water-management obligations.

A Phased Market Architecture, Not a Supranational Regulator

The report proposes building the market architecture in phases, on top of existing mechanisms, rather than through the immediate creation of a supranational market.

- The first level consists of bilateral transactions, coordinated dispatch schedules, settlement metering, rules for settling deviations, and emergency mutual assistance.
- The second level consists of a limited “day-ahead” market with confirmed available transmission capacity.

- The third level introduces real-time balancing and ancillary services, including frequency response, operating reserves, voltage and reactive-power support, and emergency assistance.
- The fourth level establishes regional resource adequacy assessment and rules for recognizing dependable cross-border resource contributions.

National system operators retain full control over domestic system operation at every stage. As transparency and settlement reliability improve, CDC Energia could assume selected functions as regional coordinator, market-platform operator, and settlement coordinator. Market-power monitoring and dispute resolution, however, should remain organizationally separate from these functions. This separation is a prerequisite for participant confidence, not a technical design detail.

Investment priorities, including grid projects (Shymkent–Tashkent TPP, Muruntau–Shymkent, Kemin–Almaty, Frunze–Kemin, Kristall–Yulduz, Datka–Sughd) and digital infrastructure (the AGC Coordination Center, wide-area monitoring, secure communications), should be assessed against measurable system-wide outcomes: higher available transfer capacity, lower congestion and curtailment of RE, and improved reliability.

External Corridors: Five Routes with Varying Levels of Maturity and Risk Profiles

External corridors should be treated as a portfolio of options whose value increases as the internal controllability of the CAPS improves. Each route has a different combination of technical maturity, commercial opportunity, and external risk.

- The Northern Vector (Kazakhstan–Russia/EAEU) is the most mature external reliability link. Kazakhstan’s North–South corridor, with a transfer limit of about 2.1 GW in the operating conditions considered, already supports balancing and, as demonstrated in 2022, emergency assistance. Its value depends on the reliability of Kazakhstan’s internal transmission network and on external regulatory conditions.
- The Southern Corridor (CASA-1000) provides a route for seasonal hydropower exports to South Asia. Its sustainable utilization depends on residual summer export availability, the Datka–Sughd and Afghan sections, water conditions, and the political and institutional environment in Afghanistan.
- The Eastern Route (China) offers access to a potentially large market, but requires a confirmed creditworthy offtaker, an agreed technical configuration, and a bankable long-term contractual model.
- The Trans-Caspian Green Corridor offers a long-term option for certified green electricity exports to Europe, but remains at an early feasibility-study stage.
- The Turkmenistan–Iran route depends primarily on the synchronization architecture and the possible use of a controllable HVDC interconnection.

No external corridor is free from factors outside the region’s control. Planning for reserves, firm imports, and export commitments should therefore explicitly reflect route-specific availability and external risk.

Market Development Roadmap

The proposed roadmap is a sequence of maturity levels, not a rigid timeline.

- In 2026–2028, priorities should include settlement metering, telemetry, secure data exchange, coordinated dispatch schedules, a transaction registry, imbalance-settlement rules, emergency-energy accounting, inter-operator balancing-energy exchange, and preparation for pilot trading. The objective is a transparent operating framework in which every delivery is metered, every transaction has a schedule and balancing responsibility, and every deviation is settled under predefined rules.
- In 2028–2030, the focus may shift to implementing priority grid upgrades, calculating NTC/ATC, expanding AGC and WAMS/WACS, updating requirements for RE sources and BESS, launching a pilot “day-ahead” market, and developing payment mechanisms for balancing energy and ancillary services.
- After 2030, once the necessary maturity is achieved, full-scale real-time balancing, regional resource adequacy assessments, recognition of cross-border contributions of reliable capacity, the development of more sophisticated cost-sharing mechanisms, and the expansion of external corridors may become possible.

Transition between stages should be governed by measurable readiness criteria: data and metering quality, resolution of discrepancies, reserve availability, growth in NTC/ATC, lower curtailment of RE, payment discipline, and institutional readiness.

Central Asia already has power lines. What is still lacking is an “architecture of trust” among countries, operators, and investors; without it, the power lines may remain nothing more than lines on a map.

This architecture rests on practical institutional and technological foundations. Settlement metering, secure data channels, and wide-area monitoring make cross-border flows visible. Imbalance-settlement rules and independent market monitoring make them predictable. Day-ahead trading and ancillary services then convert this predictability into price signals for generation, reserves, and storage. Remuneration of hydropower flexibility and transparent benefit sharing make cooperation durable rather than dependent on ad hoc goodwill.

For the Eurasian Development Bank, regional electricity cooperation creates a distinct class of cross-border investment opportunities whose benefits extend beyond a single country. The Bank can add value not only through financing, but also by translating CAPS constraints into investment-ready projects through technical diagnostics, economic appraisal, benefit- and cost-sharing mechanisms, and intergovernmental dialogue. Priority should go to projects with measurable regional benefits: higher available transfer capacity and reliability, lower curtailment of RE, and greater scope for trade and shared flexibility.