



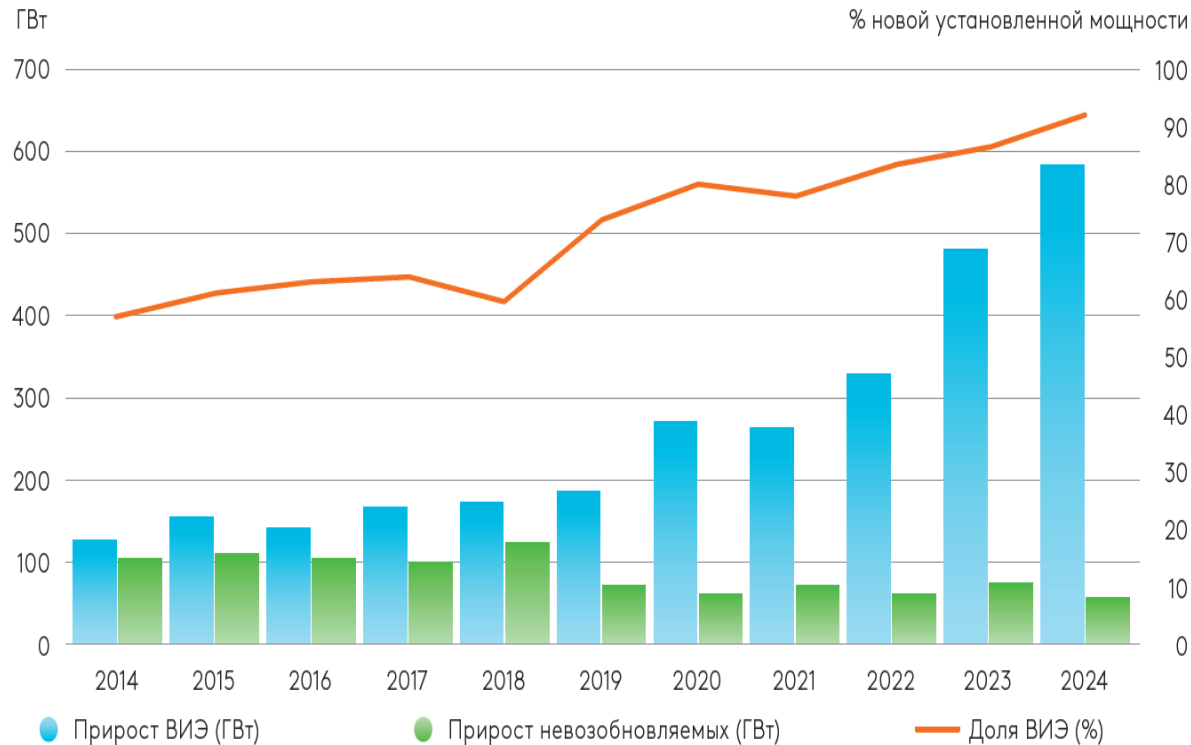
Евразийский Банк Развития

Power Sector of Central Asia: modernization and energy transition

March 19, 2026

The global energy transition has gained significant momentum over the past 10 years...

Growth in new installed capacity worldwide



Source: IRENA, 2025

92%

share of renewable energy in all new capacity in 2024

-70%

Decrease in the cost of solar power since 2015

-55%

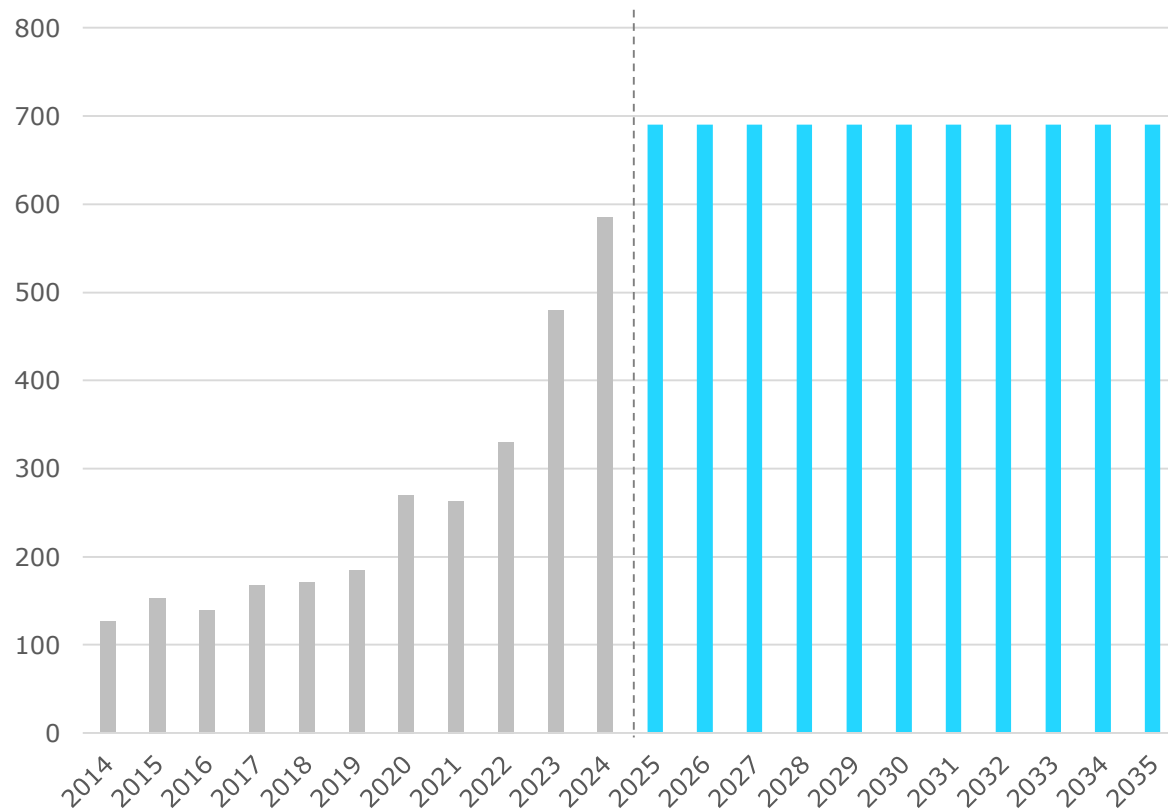
Decrease in the cost of wind power since 2015

\$2.2 trillion

Investment in the energy transition in 2024 (2x investments in fossil fuels)

...however, the future trajectory remains uncertain due to four key challenges

Illustrative estimate of average renewable energy capacity growth until 2035, GW



Source: IEA - World Energy Outlook, 2025

1

Network infrastructure is not keeping pace with capacity commissioning

>3000 GW

renewable energy projects awaiting connection permits

up to 7 years

waiting time

2

The total cost of renewable energy is increasing due to balancing costs

+100%

of the cost of renewable energy

3

Rising interest rates and capital costs

+2-4%

in recent years

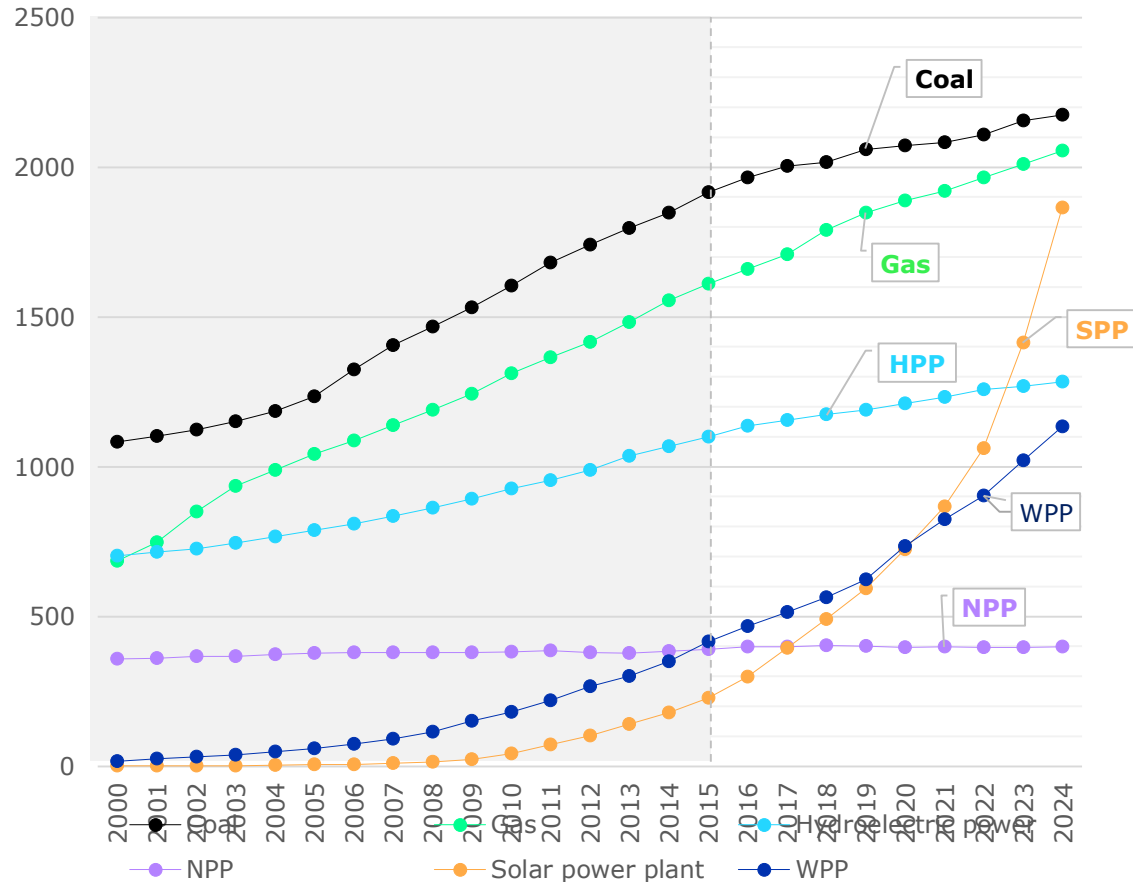
4

Declining effectiveness of incentives

New conditions and **market risks**

In terms of energy production, renewable energy sources are changing the traditional landscape

Trends in installed capacity of various technologies, GW



Source: Ember Electricity Data Explorer

10Y CAGR

Coal =	1.3%	Declining in most countries Growth driven by China and India
Gas ↑	2.5%	Growth in most countries (USA, Middle East, etc.)
HPP ↑	2.5%	Moderate growth Maneuverable clean generation
Solar ↑↑	26.8%	The fastest growing (in GW) technology in history (CAGR +27%)
Wind ↑↑	10.0%	Higher output Leaders: China, USA, Germany
Nuclear =	0.3%	Growth prospects Review of MBR positions
Average	1.6%	

In response to these challenges, a "middle path" strategy was formulated



CONSERVATIVE SKEPTICISM

"Renewables are a scam"

- Focus on traditional 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

- Modernization of existing thermal power plants and phased withdrawal
- Development of renewable energy sources and energy storage systems
- Development of flexible capacity (gas) for balancing
- Recognition of the role of nuclear energy
- Accelerated construction of grid infrastructure
- A just transition for affected industries



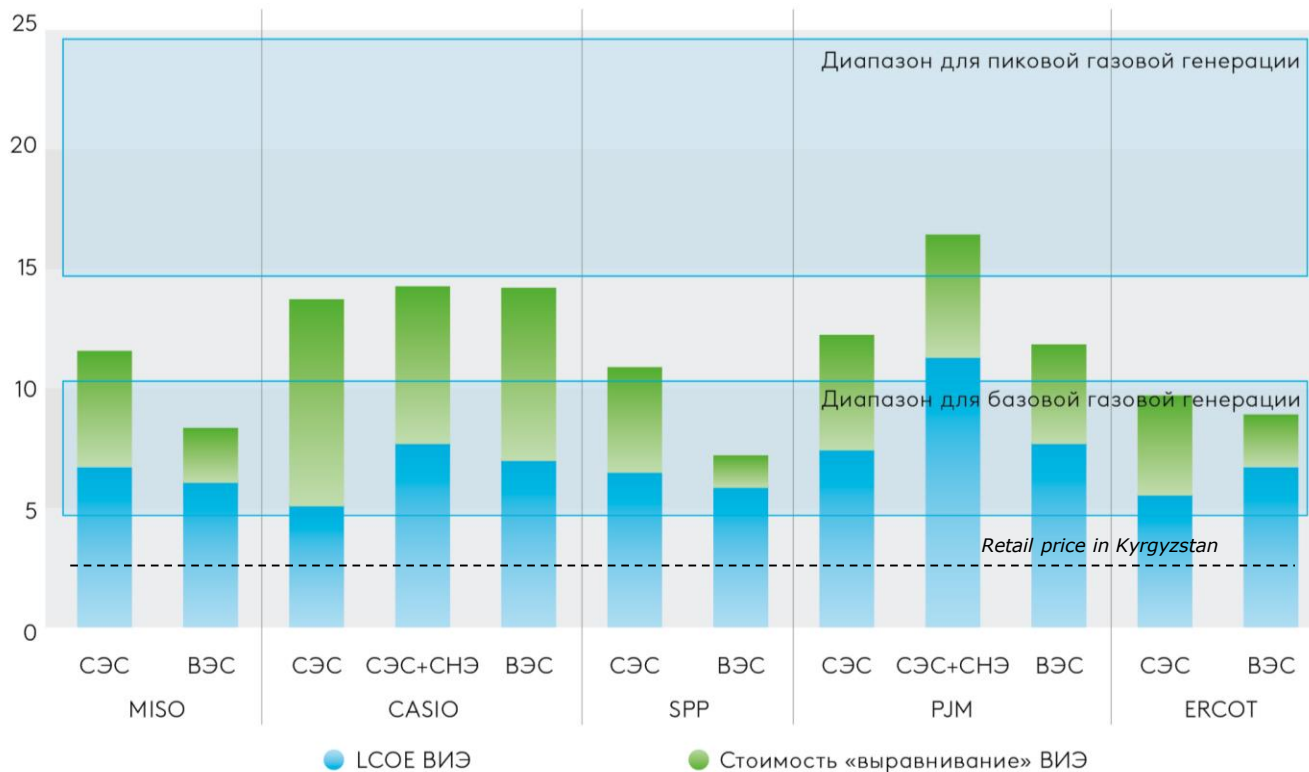
GREEN MAXIMALISM

"Renewables are a panacea"

- Rapid decarbonisation, even at the cost of short-term economic losses
- Complete phase-out of coal and internal combustion engines by 2040
- Large-scale expansion of renewable energy 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

Ensuring system reliability and security are becoming key issues in the energy transition

Average cost and cost of "firming" renewable energy sources for different grid operators in the US, cents/kWh



Integrating variable renewables requires **additional costs**

The **ancillary services** market is becoming more important

Focus on **batteries, gas peaking plants, hydropower,** and demand response

Source: Lazard (2025)

Thus, for many countries, choosing the optimal technology mix becomes a non-trivial task

Technology/fuel	Total installation cost (USD/kW)	Specific cost* (cents/kWh)	GHG emission factors (gCO ₂ /kWh)	Ability to control generation	Balancing capability
Onshore wind energy	1000	3.4	12	No	No
Solar energy	700	4.3	46	No	No
Offshore wind energy	2800	7.9	12	No	No
Bioenergy	3200	8.7	18	Yes	Low
Geothermal energy	4000	6.0	45	Yes	Low
Natural gas	2400	5-11	469	Yes	High
Oil (ICE)	2200	7-15	840	Yes	High
Coal	4000	7-17	1001	Yes	Low
Nuclear	5000	8-25	16	Yes	Low

Source: IRENA, IPCC, Lazard

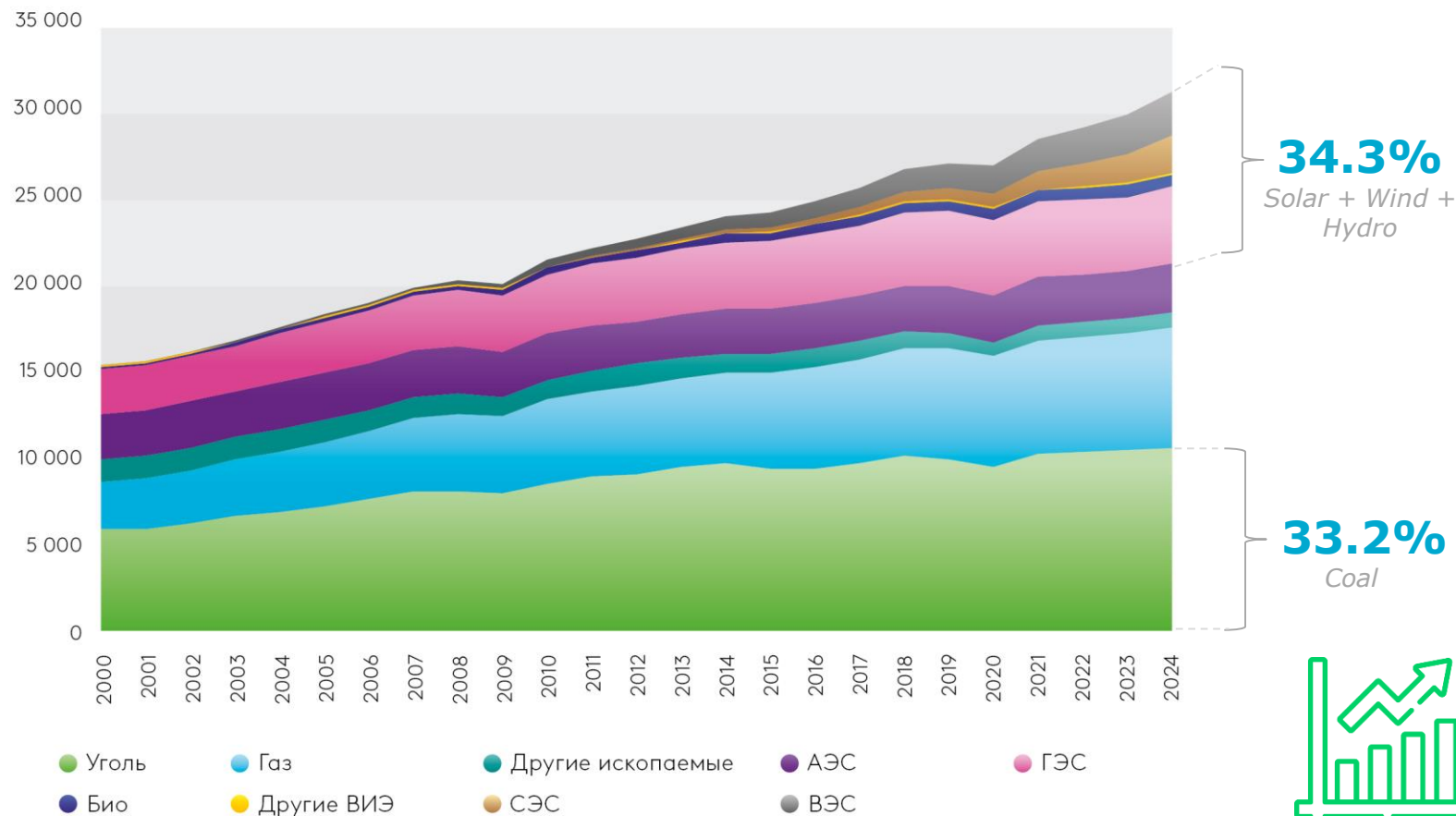
*Depends on the cost of capital



Comparing technologies in terms of cost and development prospects makes it possible to determine the optimal trajectories for diversifying the energy balance

Electricity demand has grown faster than renewable energy deployment in recent years, especially in developing countries

Global electricity generation mix, billion kWh



Source: Ember, 2025

Renewable energy production exceeded coal-based electricity generation for the first time

Global energy demand **grew by 2.2%** in 2024, compared to 1.3% (average rate over 10 years).

Stagnation or moderate growth in developed countries and China

Significant growth in Southeast Asia, South America, and the Middle East



The concept of the energy trilemma is useful for a balanced approach to the development of the energy sector



Energy security

implies the ability to reliably ensure current and future energy consumption, resilience to disruptions, and rapid recovery from external shocks



Energy accessibility and equity

means guaranteed universal access to basic energy services at affordable prices



Environmental sustainability

requires minimizing the negative impact of energy on the environment and climate

Энергетическая безопасность

Диверсификация первичных энергоресурсов	Диверсификация генерации электроэнергии	Надежность и устойчивость энергосистемы
Зависимость от импорта	Хранение энергии	



Энергетическая справедливость

Доступность электроэнергии	Доступ к современным энергоуслугам	Цены на электроэнергию	Цены на бензин и дизель
Доступ к чистым источникам энергии для готовки		Цены на природный газ	Доступность электроэнергии для населения



Энергетическая устойчивость

Энергоемкость ВВП	Динамика выбросов CO ₂	Углеродоемкость производства	Выбросы CO ₂ и CH ₄ на душу населения
Потери в сетях передачи и распределения	Развитие низкоуглеродной генерации	Загрязнение частицами PM2.5	Загрязнение частицами PM10



Source: adapted from the World Energy Council

One goal should not be achieved at the expense of others

An analysis of the region's energy sector within the framework of the trilemma revealed a number of challenges



Energy security

- Outdated thermal and hydroelectric power plants
- High network wear (60–70%) and losses (up to 20%)
- Insufficient diversification of generation
- Outpacing demand growth
- Low reserve capacity and lack of balancing assets
- Low level of cross-border trade
- ...



Energy equity

- Tariffs below cost
- Power outages
- Cross-subsidization
- Lack of targeted support for vulnerable groups
- High share of centralized heat supply
- Risks for single-industry towns
- ...

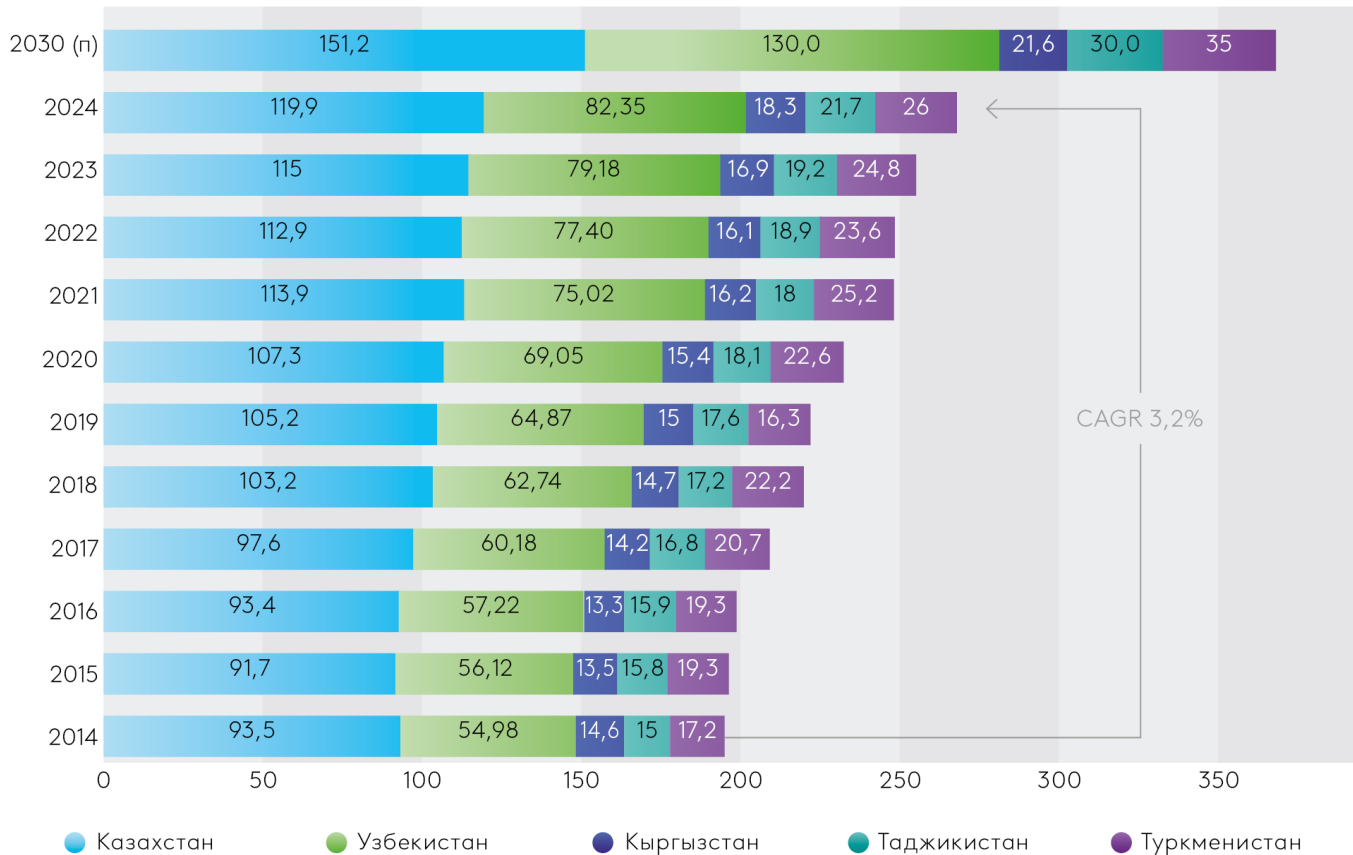


Sustainability

- High carbon intensity of the economy
- Risk of carbon regulation
- High dependence on hydropower amid declining water availability
- Potential conflicts in the water-energy nexus
- Climate change
- ...

Significant growth in demand is expected, along the existing electricity shortage in the region

Historical demand and forecast for electricity consumption, billion kWh



Source: EDB calculations based on historical data and forecasts from the World Bank and energy ministries

3.2%
p/a

Demand growth rate in **2014-2024**

5.4%
p/a

Demand growth rate (forecast) in **2024-2030**

Growth drivers

energy-intensive industry

population growth and urbanization

digitalization

data centers, crypto mining, EV



All countries have set ambitious targets for the development of RE sources and conventional generation

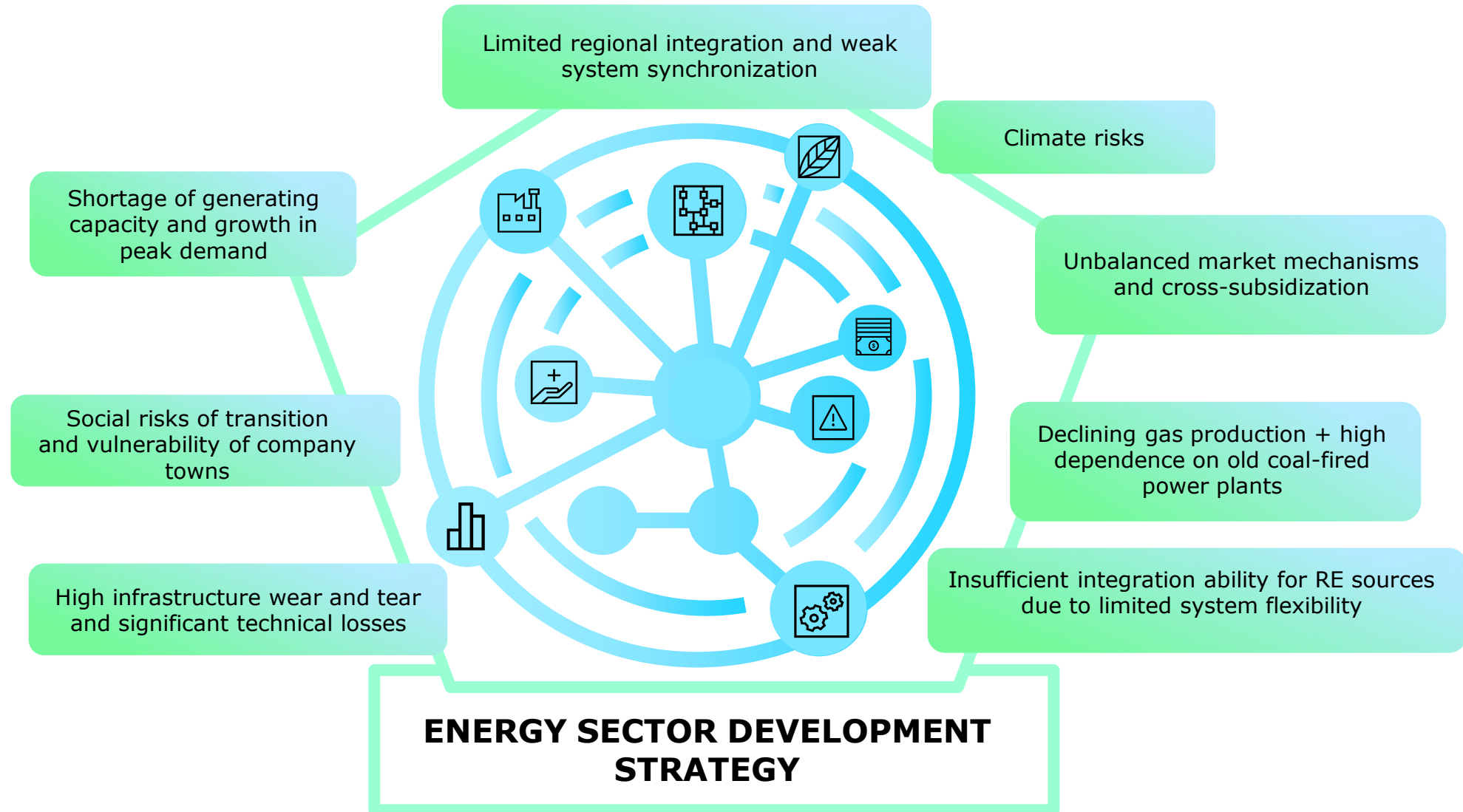
Country	Traditional generation targets	RE development targets
Kazakhstan	<ul style="list-style-type: none"> • 12 GW of coal and gas generation, nuclear power plants • 5.5 GW reconstruction of existing thermal power plants 	<ul style="list-style-type: none"> • 15% of electricity from renewable energy sources by 2030 • 8.4 GW of renewable energy by 2035 • 50% of electricity from renewable energy sources by 2050
Uzbekistan	<ul style="list-style-type: none"> • Reconstruction of 3 GW of thermal power plants • 1 large and 1 small modular nuclear power plant 	<ul style="list-style-type: none"> • >25 GW of renewable energy • 54% of electricity from renewable energy sources by 2030
Kyrgyzstan	<ul style="list-style-type: none"> • 4.6 GW of new large HPPs • 80 MW of small-scale HPPs • Reconstruction of existing HPPs 	<ul style="list-style-type: none"> • 3,650 MW of solar power plants • 400 MW of wind power plants by 2035
Tajikistan	<ul style="list-style-type: none"> • Completion of the Rogun HPP • 2 GW of new HPPs • Reconstruction of existing HPPs 	<ul style="list-style-type: none"> • 2,000 MW of solar and wind power plants by 2030.
Turkmenistan	-	<ul style="list-style-type: none"> • 300 MW solar power plants • 10 MW hybrid power plant

Focus on conventional thermal power plants and nuclear power plants + RE sources

Focus on large and small hydropower plants + RE sources



The development strategy should take into account the identified challenges specific to the region



Comprehensive power sector modernization: priorities for Central Asian countries



Генерация

- Modernization of existing assets
- Maneuverable reserves: CCGT, OCGT, BESS, and pumped storage hydroelectric power plants
- Low-carbon development: nuclear power plants, renewable energy sources
- Distributed generation (DG)



Рынок

- Elimination of cross-subsidies
- Pilot markets for capacity and network services
- Transparent rules for network access and PPA contracts
- Standardization of requirements for BESS and DG



Сети

- Renewal of networks and substations
- Grid digitalization: SCADA/EMS
- Smart sensors and meters
- Loss reduction program



Интеграция

- Joint reserves and coordination of regulation
- Trading of balancing services and flows
- Joint network planning
- Utilization of seasonal generation complementarity



Потребление

- Dynamic tariffs
- Energy efficiency in industry and residential sectors
- Load management for data centers, EV, and mining
- Incentives through tariffs and market signals



Переход

- Retraining of personnel and job protection
- Support for company towns: economic diversification
- Socially just transition

Power sector deserves to be highlighted as a separate sectoral focus in the EDB Strategy for 2027-2031

EDB's current portfolio

Modernization of existing assets (coal and gas generation)

- Reconstruction of CHPP-3 in Almaty with conversion to gas 500 MW
- Reconstruction of the 140 MW CHPP in Karaganda
- Reconstruction of the 100 MW CHPP in Ust-Kamenogorsk
- Expansion of the capacity of the Aktobe CHPP (+57 MW GTU)

Development of RE sources and low-carbon generation

- Bishkek Solar 300 MW
- 10 SPP with a total capacity of 305 MW in Kazakhstan
- Ereimentau Wind Farm 48 MW
- Hyperborea WPP 150 MW, etc.
- Kulanak HPP 100 MW
- Modernization of the Sevan-Razdan HPP cascade

Financing of grid infrastructure

- Construction of the interregional power transmission line "Northern Kazakhstan – Aktobe Region"
- Expansion and modernization of grid infrastructure as part of the Bank's power generation projects
- Financing of the investment program of Electric Networks of Armenia CJSC

Potential areas for future development



Introduction of advanced digital power system management



Construction of flexible power plants



Participation in the financing of large-scale nuclear energy projects



Financing the development of energy storage systems + RE sources



Introduction of hybrid power plants in isolated power systems



Financing the modernization of conventional generation as part of the transition from coal to gas



Greater focus on grid infrastructure expansion

Financing energy efficiency projects (through commercial banks)

+ Development of educational programs for power market participants, participation in the preparation of government acts in the field of power sector regulation

APPENDICES



An analysis of the region's energy sector within the framework of the trilemma reveals a number of limiting factors



Energy security

- Outdated thermal and hydroelectric power plants
- High network wear (60–70%) and losses (up to 20%)
- Insufficient diversification of generation
- Outpacing demand growth
- Low reserve capacity and lack of balancing assets
- ...
- ...



Energy justice

- Tariffs below cost
- Power outages
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- Lack of targeted support for vulnerable groups
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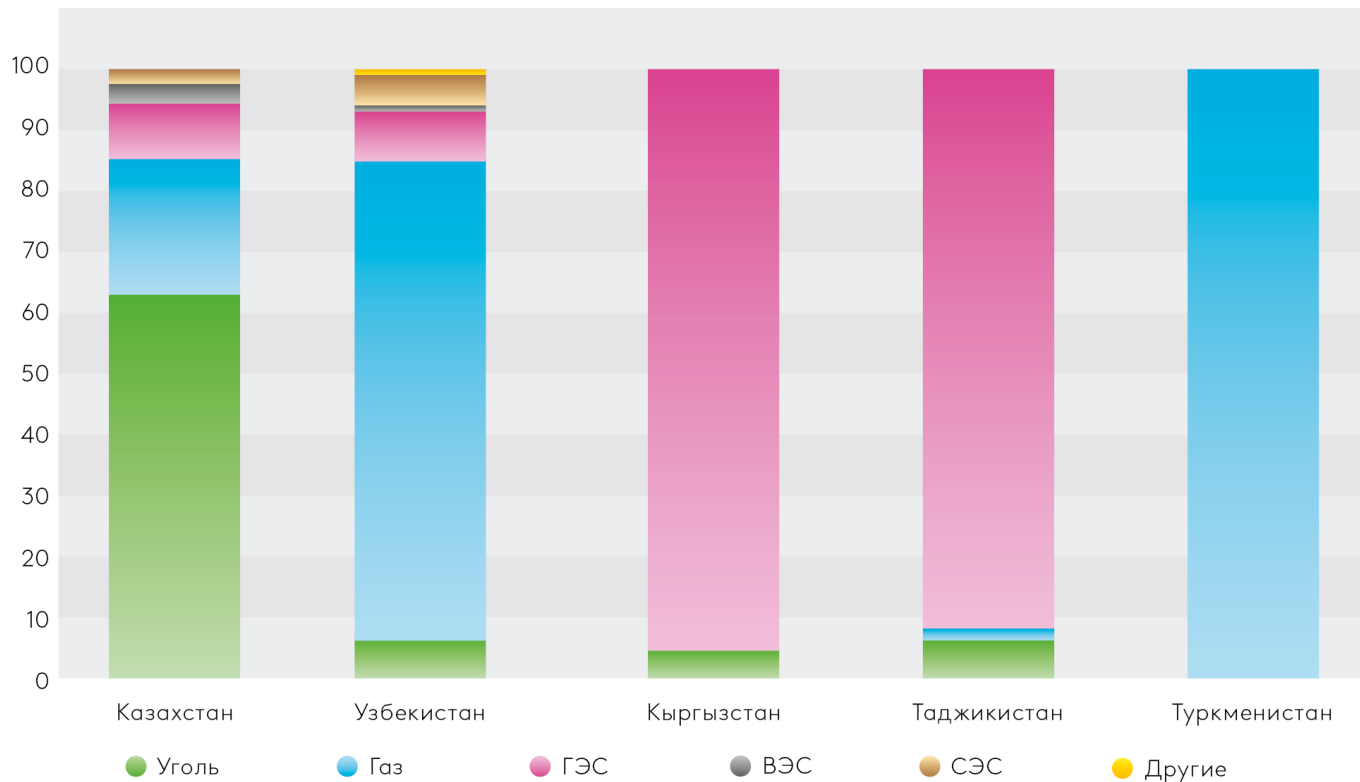


Sustainability

- High carbon intensity of the energy sector
- Risk of carbon regulation
- High dependence on hydropower amid declining water availability
- Potential conflicts in the water-energy nexus Climate change
- ...

Countries rely on one dominant source of generation, indicating low diversification

The structure of electricity generation in the region



99 Share of gas in Turkmenistan

92 Share of hydropower in Tajikistan

91 Share of hydropower in Kyrgyzstan

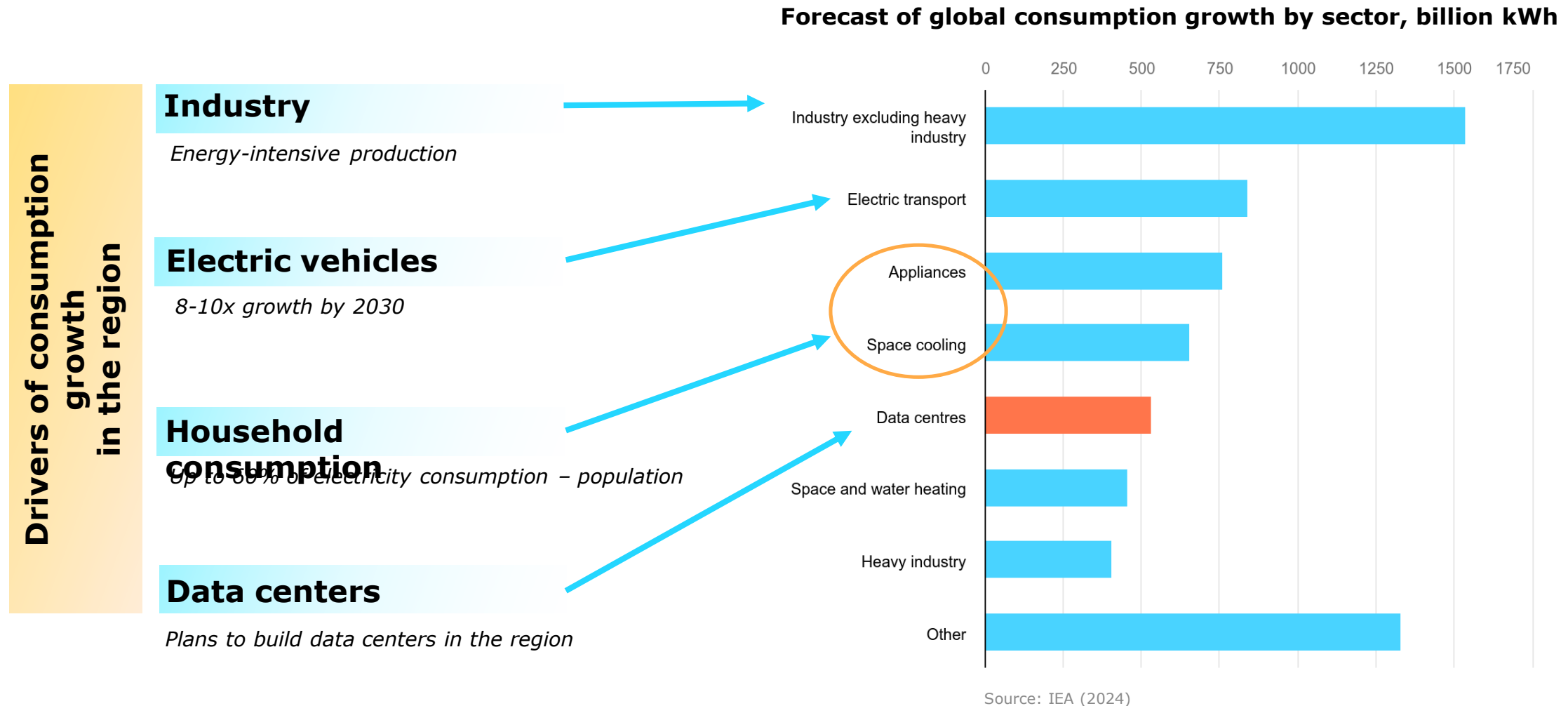
74 share of gas in Uzbekistan

63 share of coal in Kazakhstan

Insufficient diversification of generating capacity poses risks to security



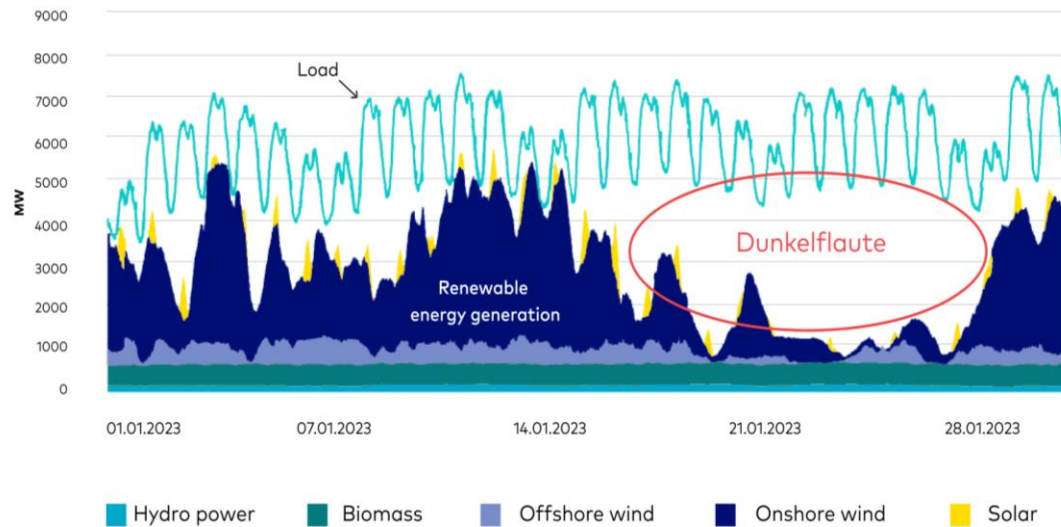
Growth in the region is linked to growth in industrial production, electric vehicles, and household consumption



The development of renewable energy sources must go hand in hand with the provision of reserves and balancing capacities

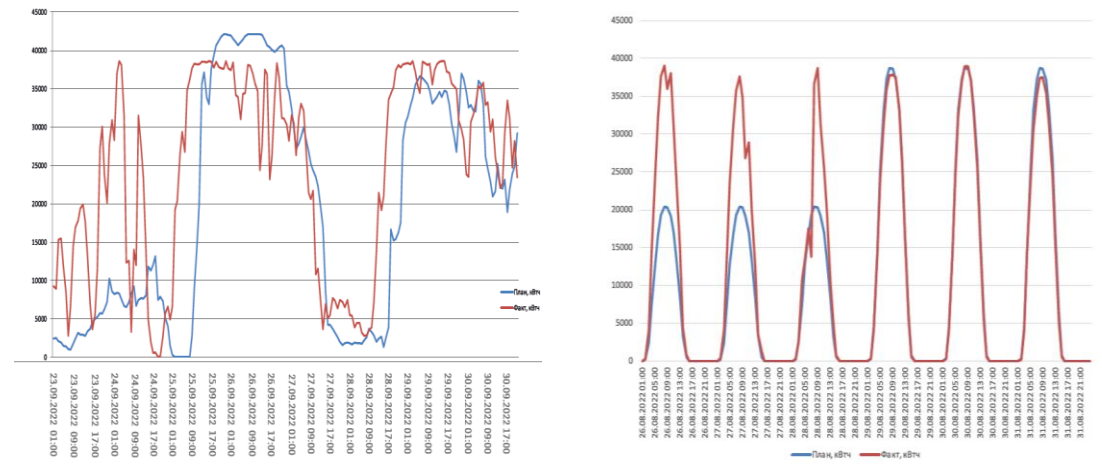
Long periods without sun and wind

Dunkelflaute in the German power system (January 2023)



Inaccuracy of renewable energy production forecasts

Discrepancies between forecasts and actual renewable energy generation in Kazakhstan



Forecasting renewable energy generation and ensuring sufficient reserves and balancing capacity are prerequisites for the development of systems with a significant share of renewable energy.

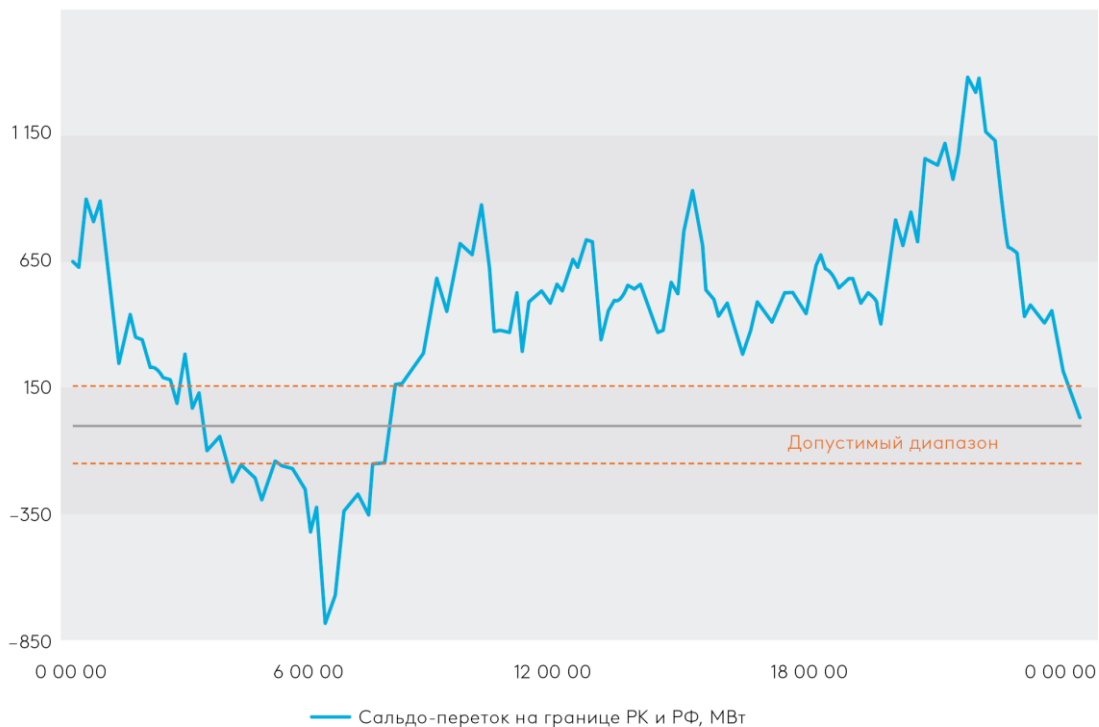


The development of balancing capacities is a key priority for the integration of large volumes of renewable energy sources

The lack of maneuverable capacity limits the development of renewable energy sources and reduces the sustainability of energy sectors

Symptom

Typical power imbalances at the Kazakhstan-Russia border (MW)



Source: QazaqGreen, Huawei (2025).

Causes

Outdated thermal and hydroelectric power plants
Growth of industry, mining, data centers, electric vehicles



Low maneuverability of the generating fleet



New sources of peak load

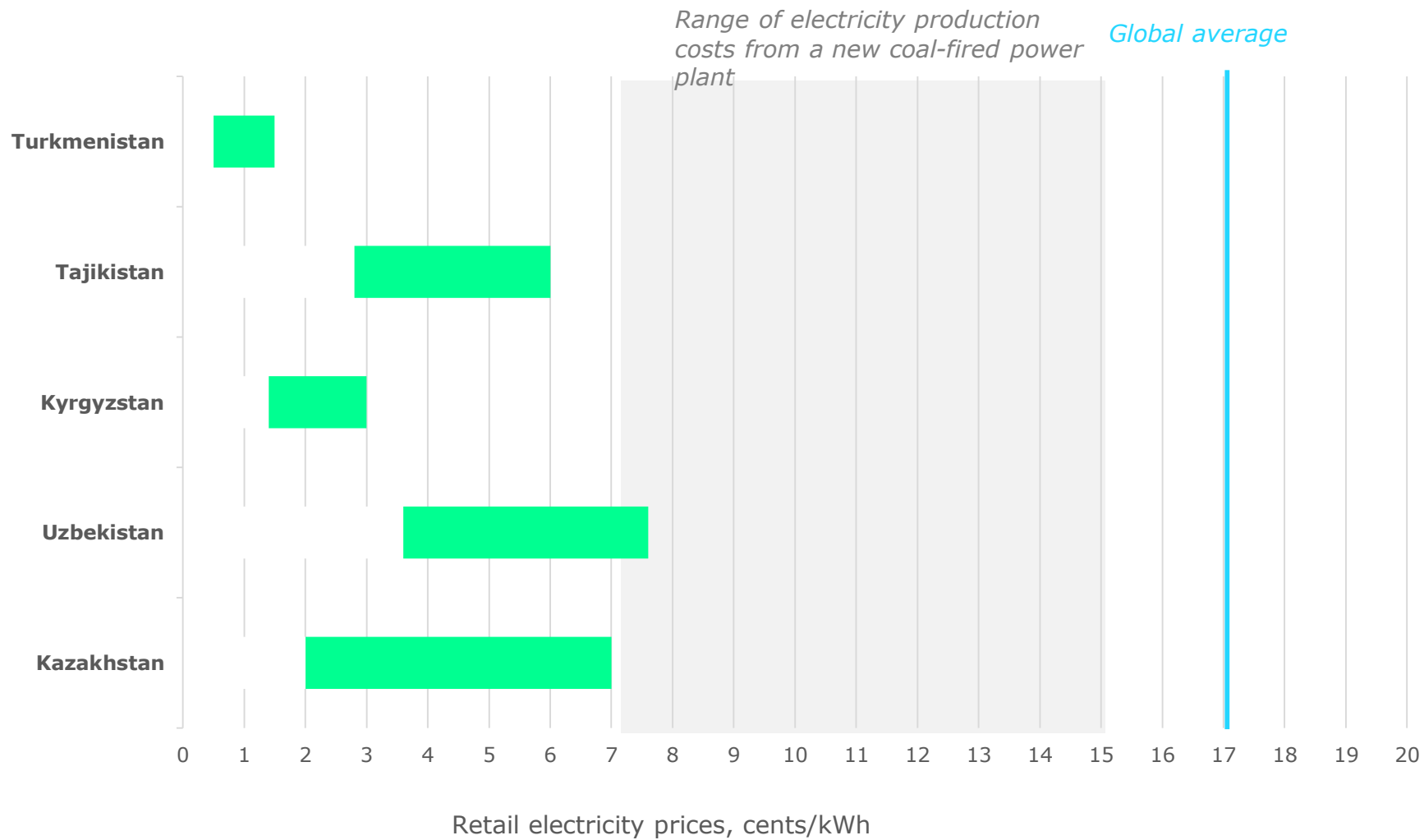
No reserves for peaks and emergencies



Regional fragmentation



Tariff policy and subsidies hinder investment in the sector



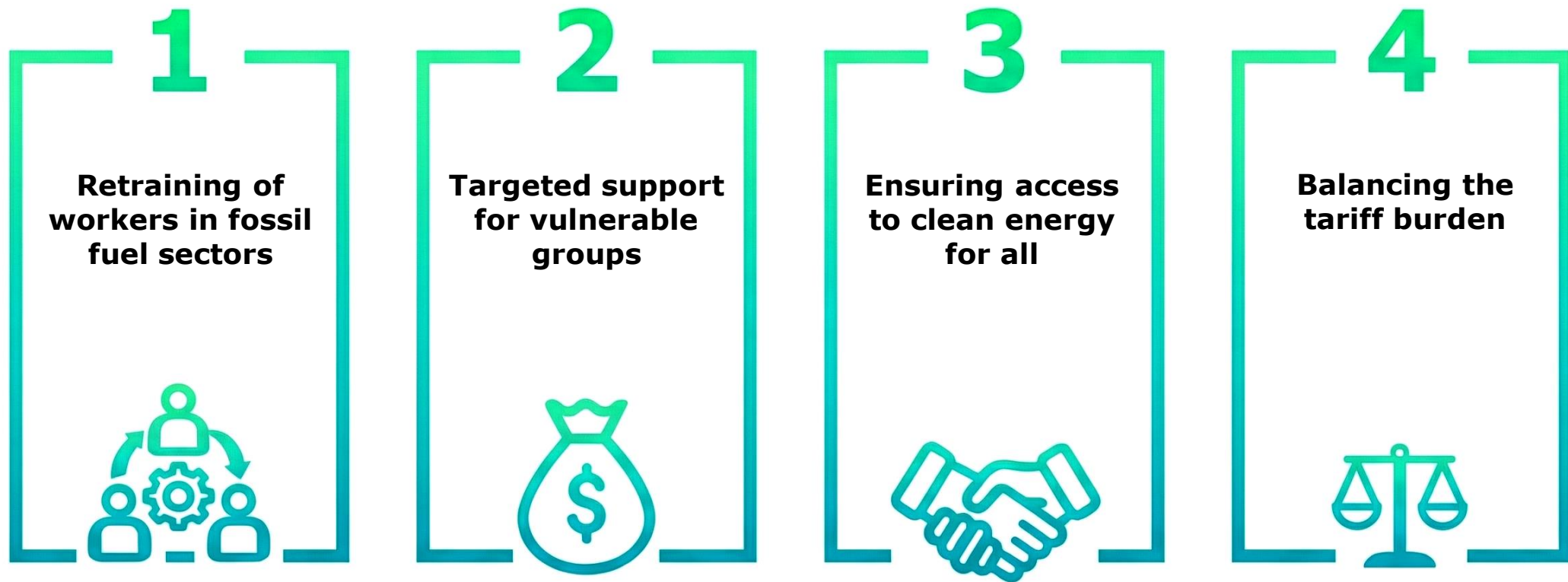
Tariffs are used as a social support tool

Tariff policy does not reflect the real cost of electricity and distorts market incentives

Source: GlobalPetrolPrices (Q3 2025), EDB calculations

The energy transition is not only technological, but also a social project

In Central Asia, the transition must be gradual and take into account the impact on jobs, households, and industries. A just transition includes:



The region is vulnerable to the effects of climate change, which are occurring faster than the global average



REDUCING ENERGY PRODUCTION FROM HYDROPOWER



INCREASE IN WATER CONSUMPTION AND EVAPORATION LOSSES



CONFLICTS OVER WATER

Change in electricity generation (GWh) from hydropower plants of the corresponding reservoirs depending on climate change scenarios

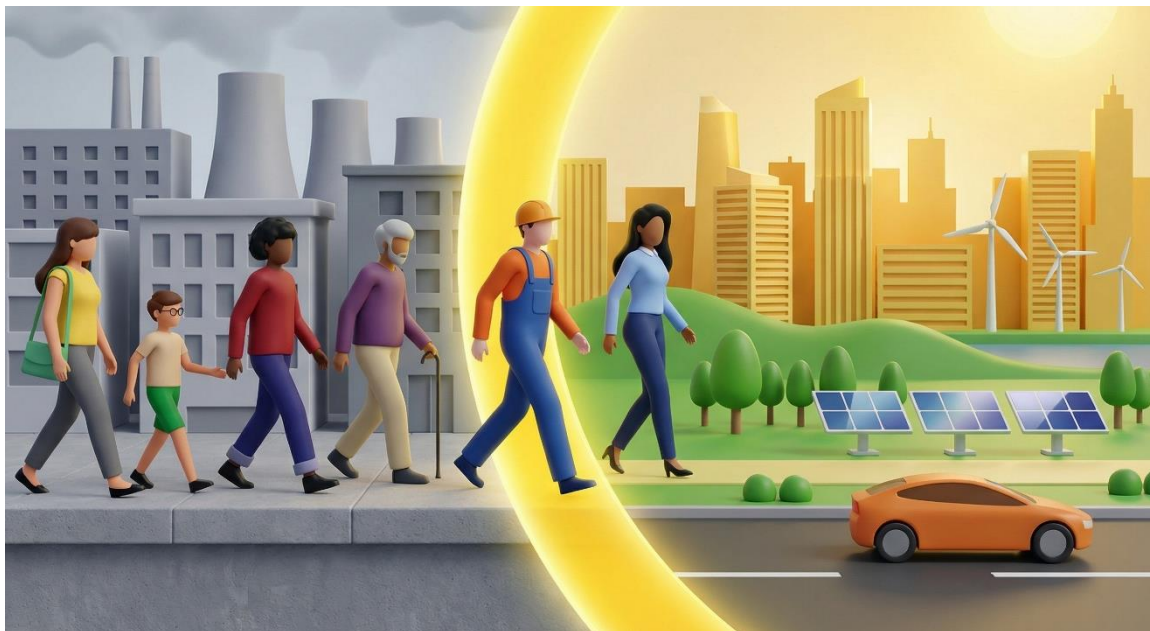
Водохранилище	Текущая выработка, ГВт·ч	Засушливый	Центральный	Жаркий/сухой	Теплый/влажный	Теплый/влажный+
Все водохранилища	33 847	-31%	-23%	-28%	-21%	-5%
Андижанское водохранилище	316	-52%	-38%	-46%	-37%	-37%
Байпазинский каскад	4 684	-35%	-29%	-29%	-27%	4%
Чарвакское водохранилище	3 013	-29%	-13%	-27%	-16%	-16%
Чирчикский каскад	1 135	-14%	-9%	-13%	-11%	-11%
Фархадское водохранилище	574	-35%	-23%	-33%	-24%	-23%
Камбарата II	527	-61%	-50%	-65%	-33%	-33%
Кайраккумское водохранилище	485	-25%	-18%	-25%	-17%	-17%
Курпсайское водохранилище	2 639	-28%	-20%	-31%	-17%	-17%
Нурекское водохранилище	11 002	-28%	-23%	-21%	-22%	13%
Шардаринское водохранилище	621	-17%	-12%	-18%	-12%	-12%
Ташкумырский каскад	3 082	-28%	-19%	-30%	-16%	-16%
Токтогульское водохранилище	4 595	-35%	-28%	-39%	-21%	-21%
Туямуюнское водохранилище	1 009	-40%	-32%	-36%	-26%	-11%

Source: World Bank

Regional cooperation, improving water use efficiency, and developing renewable energy sources can play an important role in reducing tensions in the region's water-energy nexus.



Decarbonization of the energy sector in Central Asia is a multi-level, long-term process closely linked to the economic and energy structures of the countries



Source: Binh Nguyen/Canary Media

The need for major investments

Kazakhstan alone will need **>\$600 billion** to achieve carbon neutrality by 2060.

Infrastructure constraints

Coal and gas generation account for up to **70-80%** of electricity and district heating production

Given the harsh climate and energy-intensive economy, there are currently no mature and affordable alternatives to cogeneration systems.

Low prices from depreciated thermal power plants

The cost of electricity from traditional power plants remains **2-3 times lower** than from renewable energy sources

This allows retail prices for consumers to remain low

	Electricity volume, billion kWh	Costs, billion tenge	Wholesale price, tenge/kWh
Traditional power plants	68.5	882.8	12.89
Renewable energy sources	6.6	232.1	34.80

The greenest electricity is unused electricity

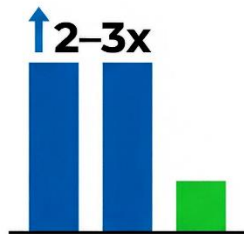
Reducing electricity transmission losses



Изношенные сети + слабый учет



Потери в сетях ЦА
в **2–3** раза выше,
чем в развитых странах



Регион



12–20%

Средний показатель
по ОЭСР



6.3%

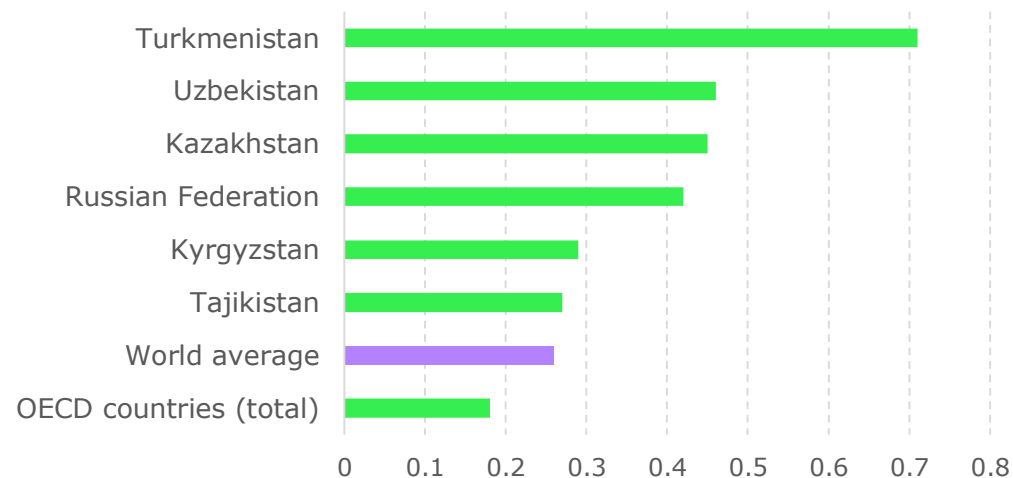


Energy efficiency is extremely important, because every kilowatt-hour saved reduces emissions and the need for additional generation.

High energy and carbon intensity of GDP

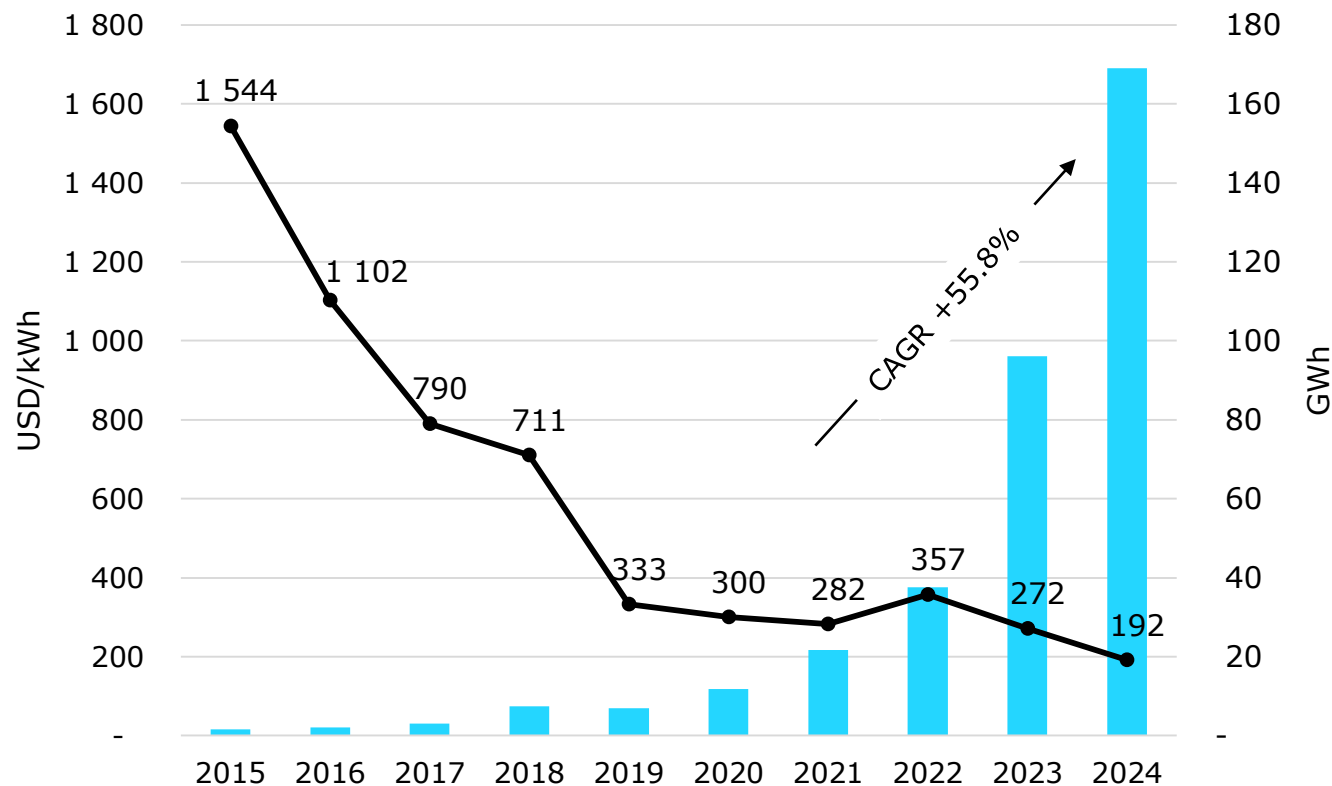
Specific energy consumption per unit of GDP in Kazakhstan and Uzbekistan is **1.5–2 times higher** than the global average.

Central Asia has enormous energy saving potential



Battery energy storage systems are a key technology for integrating renewable energy sources and maintaining grid reliability

Cost and capacity trends for electricity storage projects

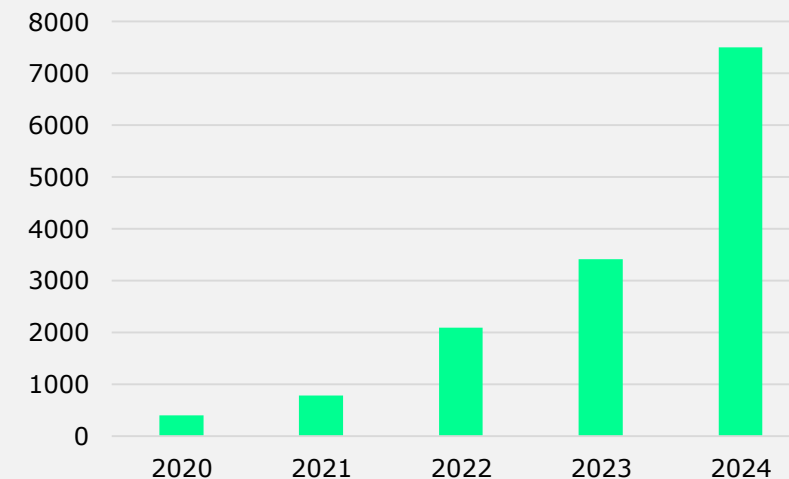


International example — Texas

7.5 GW
battery capacity in Texas in 2024

This is more than the peak load of the systems in Kyrgyzstan and Tajikistan

Total BESS capacity in Texas (MW)

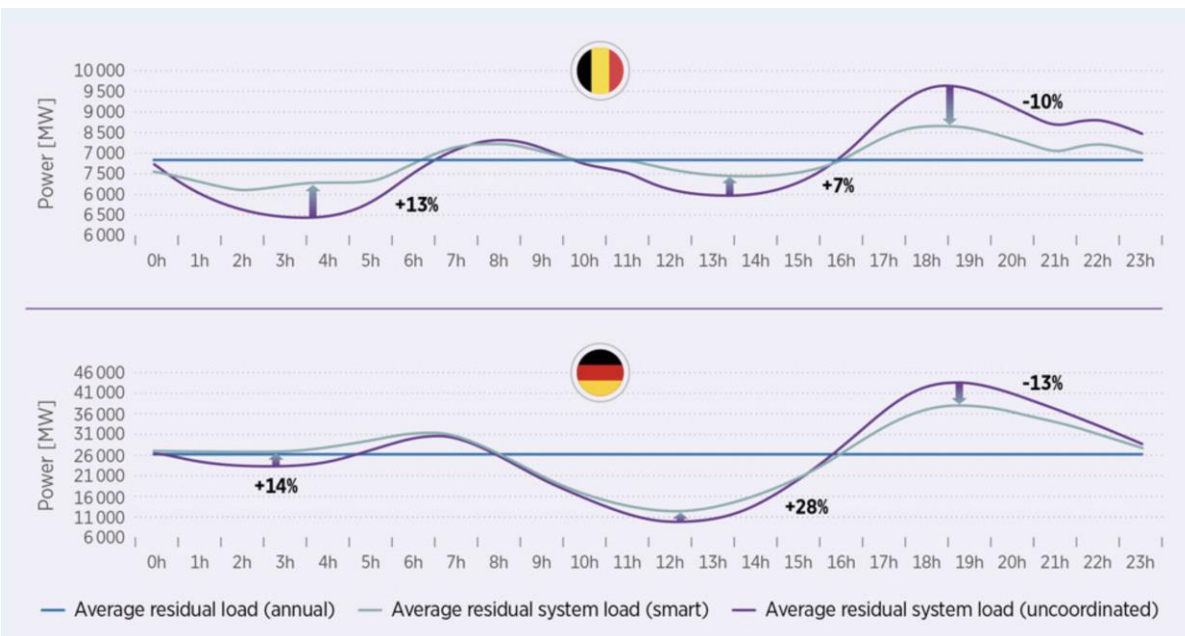


Charging a growing fleet of electric vehicles will place an additional load on the power grid

>20% — share of electric vehicle sales worldwide in 2024.

>130,000 electric vehicles in the region by mid-2025

Smart charging can reduce the load on the power grid



- Reduction in evening peak in Belgium

-13
Decrease in evening peak in Germany

>80% of the time are in parking mode

The widespread penetration of decentralized energy sources provides unique opportunities

Virtual power plant (VPP)



Benefits for the power system

Flexibility and grid balancing

Cost reduction and increased efficiency

Integration of renewable energy sources and development of decentralized generation

The introduction of the concept of virtual power plants could become an important element in improving the reliability and sustainability of energy systems



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Thank you for your attention!



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