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STRATEGIC SYNTHESIS

Global Energy Security and Lessons for Uzbekistan

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FROM THE EDITOR

This Strategic Synthesis brings together a targeted collection of analytical papers and policy assessments examining the structural transformation of the global energy landscape and its direct implications for the Republic of Uzbekistan. At a time when the global energy market is transitioning from a period of relative predictability to a state of "permanent crisis," this report seeks to provide a coherent framework for understanding the converging forces of geopolitics, technological disruption, and market fragmentation.

The period under review is defined by the collision of systemic shocks. From the escalation of conflict in the Middle East and the abrupt regime change in Venezuela to the intensifying trade war between the United States and China, the assumptions that underpinned energy security strategies for decades are being dismantled. These events are not isolated; they represent a synchronized fracturing of the global supply chain. For Central Asia, and Uzbekistan in particular, this volatility presents a complex duality: it threatens traditional export revenues and logistics while simultaneously opening a "window of opportunity" for accelerated decarbonization and industrial modernization.

This report moves beyond episodic commentary to offer a structured interpretation of these dynamics. It connects the macro-level shifts—such as the "resource war" for critical minerals and the oversaturation of the renewable energy market—with the micro-level challenges facing Uzbekistan, including the gas deficit, infrastructure obsolescence, and the urgent need for cybersecurity in digitalized grids. The analysis draws on diverse international case studies, from Hungary's balanced nuclear-renewable model to Germany's energy transition, to distill actionable lessons for national policy.

A central tenet of this volume is that the traditional "buyer-seller" energy model is obsolete. The papers contained herein argue for a paradigm shift toward "energy-technological clusters," exemplified by the proposed deep integration with Turkmenistan and the strategic expansion of the C5+1 platform. The synthesis emphasizes that energy security in the 21st century is no longer solely

about accessing hydrocarbons, but about mastering the technologies to extract, process, and manage resources efficiently and securely.

We present this Strategic Synthesis not merely as an academic exercise, but as a roadmap for decision-makers navigating the "Great Eurasian Realignment." By clarifying strategic choices—from nuclear integration to critical mineral value chains—this report aims to equip policymakers and practitioners with the foresight necessary to transform vulnerability into resilience. It is our hope that this volume will serve as a foundational text for constructing a robust, independent, and future-proof energy strategy for Uzbekistan.

EXECUTIVE SUMMARY

The modern architecture of the global energy market is undergoing a period of radical transformation, characterized by a transition from an era of relative stability to a state of "permanent crisis." Geopolitical upheavals—from the escalation of the conflict between Israel and Iran to the forceful regime change in Venezuela in early 2026—are creating unprecedented volatility in hydrocarbon prices, forcing nations to rethink their survival strategies.

For the Republic of Uzbekistan, situated at the heart of Central Asia, these challenges are multi-layered. On one hand, the intensifying trade war between the U.S. and China leads to a slowdown in global oil demand while simultaneously oversaturating the market for renewable energy (RE) equipment, opening a "window of opportunity" for accelerated decarbonization. On the other hand, the critical dependence of the global "green" industry on rare earth elements (REEs) from China turns the region's resource base into an arena for great power competition.

This report provides a comprehensive analysis of international experience (Germany, Japan, USA, China, Hungary) and regional vectors (Turkmenistan, Azerbaijan). The primary goal of this study is to adapt the best global practices to solve Uzbekistan's internal challenges: eliminating the gas deficit, deeply modernizing infrastructure, and transitioning to a new "energy-technological cluster" model. The methodology relies on cross-country analysis, cyber risk assessment, and a critical minerals audit to form a roadmap for energy independence amidst the "Great Eurasian Realignment."

1. Geopolitical Conflict and Oil Market Volatility

Israel-Iran Conflict Scenarios

The confrontation between Israel and Iran threatens the stability of Middle Eastern supplies, with potential price spikes comparable to the 1970s oil crises.

- **Short-term:** Minimal impact if strikes avoid critical infrastructure.
- **Escalation ($100–$150/barrel):** Targets on refineries or export terminals would reduce supply significantly.

- **Energy Shock ($200–$300+/barrel):** Closure of the Strait of Hormuz, where one-fifth of global consumption passes, would trigger a global domino effect: logistics cost spikes, inflation, and a contraction of global GDP by 1-2%.

The Venezuela "Black Swan" (2026)

The early 2026 regime change in Caracas shifted control of 303 billion barrels of oil—the world's largest reserves—toward a "Pan-American Energy Alliance." This shifts the long-term balance of power away from OPEC+ but creates immediate volatility due to infrastructure decay and the "Heavy Oil Crunch" affecting global diesel production.

2. Strategic Vulnerabilities: Critical Materials and Trade Wars

Europe's Dependence on China

Every segment of modern defense and high-tech industry is linked to China, which controls:

- **100%** of heavy rare earth elements.
- **97%** of magnesium and **79%** of lithium.

Without these, precision weapons, satellites, and drones cannot be manufactured. China acts as the "Global Valve," determining the military and technological potential of other nations.

US-China Trade War Impacts

Protectionist measures have closed US markets to Chinese solar panels, leading to a global price crash for RE equipment. While this benefits Uzbekistan's green transition, the trade war halves China's oil demand growth, creating a structural surplus and downward pressure on global energy prices.

3. Regional Dynamics: The Central Asian Perspective

Azerbaijan-China Strategic Partnership

The June 2025 agreement between Azerbaijan and CEEC for green energy interconnectors serves as a blueprint for Uzbekistan. It emphasizes joint research centers and grid integration simulations, shifting Azerbaijan from a fossil-fuel exporter to a green energy hub.

The Uzbekistan-Turkmenistan "Energy-Technological Cluster"

The traditional "buyer-seller" model is obsolete. A proposed unified cluster (2025–2030) includes:

- **Long-term Off-take contracts** based on the Netback formula.
- **"Storage as a Service":** Storing Uzbek gas in Turkmen reservoirs.
- **Seasonal Swaps:** Exchanging Uzbek solar/wind surplus for Turkmen gas generation.

- **Joint Ventures:** Uzbek entities (Uzbekneftegaz, Eriell, SANEG) providing technology for Turkmen upstream projects.

4. Institutional Lessons: The Hungarian Model

Hungary serves as a pragmatic example for Uzbekistan, balancing a baseline of nuclear power (42%) with a rapid rise in solar (32%).

Recommendations based on Hungary:

- **Institutional Independence:** The Atomic Energy Authority must be accountable only to Parliament.
- **Educational Foundation:** Sending Uzbek students to Hungarian technical universities to build a non-Russian-dependent expertise base for nuclear and grid management.
- **Decentralized RES:** Focusing on domestic and municipal solar installations rather than just utility-scale plants.

5. Cybersecurity and Digital Resilience

As Uzbekistan digitalizes its grid, it becomes a target for transboundary cyberattacks.

- **Vulnerability:** Dependence on imported platforms (RU, CN, EU) without integrated network segmentation.
- **Strategic Need:** Implementing **ISA/IEC 62443** and **ISO 27019** standards.
- **Regional Coordination:** Creating a "Sectoral Security Operations Center (SOC)" and a "Regional Information Sharing Center (ISAC)" to prevent cascading blackouts in the Unified Energy System of Central Asia.

6. The C5+1 Platform and Strategic Alliances

The C5+1 format (Central Asia + USA) should evolve into a practical technological platform.

- **Methane Initiative:** Using US technology (Honeywell, Baker Hughes) to reduce leaks in gas infrastructure.
- **Critical Minerals Audit:** Partnering with the **USGS** to map lithium and REE reserves, ensuring Uzbekistan receives technology rights, not just rent.
- **Uranium Diversification:** Developing conversion and enrichment capacities in Uzbekistan with US investment to reduce global dependence on Russian and Chinese fuel cycles.

7. Strategic Recommendations for Uzbekistan

1. **Aggressive Critical Mineral Strategy:** Capitalize on the global "resource war" by attracting Western investment into the processing (not just extraction) of lithium, cobalt, and rare earths.

2. **Triple Land Connectivity:** Solidify Uzbekistan's role as the Eurasian logistics hub (CKU Railway, Middle Corridor, Southern Afghan Corridor).

3. **Nuclear Integration:** Use the Jizzakh SMR and large NPP projects to stabilize the base load, while strictly diversifying technical oversight and safety training through international (IAEA, EU) partnerships.

4. **Energy Efficiency & Reform:** Accelerate domestic gas market reforms to eliminate subsidies and attract private investment into aging production assets.

5. **Strategic Reserves:** Build three-month strategic reserves of petroleum products and expand underground gas storage to mitigate seasonal volatility.

How the conflict between Israel and Iran will affect the cost of oil on the global market

The conflict between Israel and Iran, despite its regional nature, is capable of causing global upheavals in the oil market. The escalation of tension in the strategically important region of the Middle East threatens the stability of oil supplies, and in extreme scenarios, can cause shock price spikes comparable to the oil crises of the 1970s.

1. Short-term conflict - minimal impact

If the military confrontation develops according to the scenario of the previous exchange of strikes — that is, briefly, without significant infrastructure losses and the involvement of third countries — the reaction of the oil market will be restrained. An example is the episode in the spring of 2024, when after the exchange of strikes on targets in Syria, Iraq and Iran, oil prices temporarily rose by $3-5 per barrel, but returned to previous levels a week later. In such situations, the market factors a "geopolitical premium" into the price, but quickly corrects when it becomes clear that there is no threat to real supplies. Moreover, Iran supplies about 1-1.5 million barrels per day to the foreign market — this is a significant, but not critical volume, especially if it goes mainly to China, which has its own strategic reserves.

2. Escalation and strikes on infrastructure - price growth to $100-150

A scenario in which the conflict drags on and Iran's oil refineries, export terminals and pipelines fall into the affected area poses a much greater threat. In this case, the market will face a real reduction in supply, which could provoke a price jump to $100–150 per barrel. There have already been precedents of this kind — a drone attack on Saudi Aramco facilities in September 2019 led to the loss of almost 5% of global supplies and caused a simultaneous increase in Brent crude oil prices by 19% (the sharpest jump since 1991). Although the situation was quickly settled, it highlighted the vulnerability of the infrastructure of even highly protected countries. Given the limited possibilities of increasing production in the short term, even for OPEC+ countries, and the possible tightening of sanctions against Iran, it will be difficult for the market to quickly compensate for the loss of even 1-1.5 million barrels per day.

3. Threat to the Strait of Hormuz - energy shock scenario

The most critical scenario is related to the closure or military blockade of the Strait of Hormuz — a strategic "oil bottleneck". Between 20 and 21 million barrels of oil pass through this narrow stretch between Oman and Iran daily, which is about one-fifth of total global consumption. Iran has repeatedly threatened to close the strait in the event of military aggression. If such a threat becomes a reality, even for a few days, oil prices could jump sharply to $200-300 per barrel. In the event of a large-scale naval blockade, the refusal of insurance companies to work in the region and the halt of tanker traffic, even more extreme figures are theoretically possible — $500-1000 per barrel, although they look hypothetical in the short term. This will create a domino effect:

- Global supply chains will face a sharp increase in the cost of logistics;
- Prices for gasoline, aviation fuel, food and fertilizers will rise;
- Inflationary pressure will increase in importing countries;
- Central banks will tighten monetary policy;
- Global GDP could shrink by 1-2%.

4. Deterrence factors

Despite the dramatic potential of the developments, a number of factors can restrain the explosive growth of prices:

- Strategic oil reserves in OECD countries and China are able to temporarily compensate for the drop in supply.
- The flexibility of OPEC+, especially Saudi Arabia and the UAE, allows for a rapid increase in production in case of emergencies.
- US shale oil can provide an increase in volumes of 500-700 thousand barrels per day within 3-6 months.
- Diplomatic pressure on Iran from China and Russia, who are interested in stability in the region.

At the moment, the oil market lives on expectations. If the conflict between Israel and Iran remains limited, the price increase will be short-term and moderate. However, its prolongation or the involvement of third countries (for example, the USA, Saudi Arabia, the UAE) can radically change the picture. The key risk is the Strait of Hormuz. Its closure even for a few days will provoke an energy shock and global inflation. Therefore, despite all the scenarios, the leading countries of the world are making efforts to prevent escalation to such a level.

Europe's Dependence on Chinese Critical Materials: Strategic Vulnerability in an Era of Militarization

Europe is actively discussing plans for militarization: strengthening its own defense industry, ramping up production of tanks, aircraft, drones, missiles, air defense systems, and satellites. But there is one little-discussed factor that becomes a silent yet serious bottleneck for these ambitions: critical dependence on supplies of rare earth elements (REEs) and strategic raw materials from China.

According to the data presented in the infographic (2024), Europe depends on Chinese supplies by:

- **100%** - heavy rare earth elements,
- **97%** - magnesium,
- **85%** - light rare earth elements,
- **79%** - lithium,
- **71%** - gallium,
- **65%** - bismuth,
- **62%** - vanadium,
- **45%** - germanium, baryte,
- **40%** - natural graphite,
- **32%** - tungsten.

This means that virtually every segment of Europe's military, IT, and high-tech industries is directly linked to China. Why is this so critical?

The Importance of Rare Elements for Defense and IT

- **Rare earth elements (REEs):** Essential materials for manufacturing jet engines, missile systems, precision weapons, navigation systems, magnets for electric motors, laser systems, and even electronic warfare (EW) equipment.
- **Magnesium:** Used in light alloys for aviation, armored vehicles, and missiles. Without it, no lightweight bodies or heat-resistant, high-strength parts.
- **Lithium:** The core element for batteries powering military electronics, drones, autonomous systems, and even underwater equipment.

- **Gallium, germanium:** Used in IT and electronics — for semiconductors, infrared sensors, communication systems, and radar.
- **Tungsten, vanadium:** Heavy metals critical for super-strong tools, armor, and armor-piercing rounds.
- **Scandium:** Lightens aluminum alloys for aerospace and space applications — vital for developing lightweight yet strong structures.

Why Is This Dependency Dangerous?

Any modern tank, fighter jet, drone, or missile is not just steel and armor — it's a sophisticated mix of alloys, sensors, electronics, communication modules, batteries, and composites.

Without these elements:

- tanks become heavier and slower,
- planes lose maneuverability,
- drones have limited flight time,
- missiles can't handle high stress,
- radars "go blind."

This is why Russia has long classified its REE consumption data, and why the U.S. and Europe carefully analyze supply chains. In essence, China, by controlling global supplies of rare earths and other critical elements, **effectively determines the military potential of any country**.

China's Role: The "Global Valve"

China has built this dominance over decades:

- capturing markets for cheap extraction and processing,
- overtaking the U.S. and EU in refining and separation technologies,
- acquiring stakes in African and Latin American mines.

Now, if China decides to "turn off the tap," Europe, the U.S., India, and even Japan could see the halt of production of precision weapons, electronics, satellite systems, and IT hardware.

Previously, Europe partially relied on supplies from Russia, Kazakhstan, and South Africa — but due to sanctions, geopolitics, and instability, these routes are now closed or weakened.

Europe's Prospects: What Can Be Done?

Diversifying Supply Sources: The EU is investing in rare earth projects within Europe (e.g., Scandinavia, Portugal), but mining here is more expensive and tightly regulated for environmental reasons.

Reducing Dependence Through Recycling: Recycling (e.g., from old electronics) offers only a partial solution — current volumes are too small.

Building Alliances with Africa and Latin America: The EU is seeking long-term contracts with Niger, the DRC, Brazil — but this is a slow and complex process.

Cooperation with the U.S. and Japan: Creating joint reserves, strategic stockpiles, and shared projects for processing.

While Europe debates rearmament, China remains the **invisible conductor** behind these efforts. Without access to magnesium, scandium, lithium, gallium, and rare earth elements, Europe's ambitions in defense and IT remain just plans on paper. Europe is already in a position of strategic dependence, which at any moment could turn into geopolitical vulnerability.

If tomorrow Beijing decides to limit supplies, Europe risks being left without the components needed for modern weapons systems — from drones to missiles. This is the key challenge the EU must acknowledge and address today.

Global Electricity Generation in 2024: Balancing Carbon Inertia and the Green Turn

In 2024, the global electricity generation structure once again demonstrated a strong dependence on fossil fuels—coal, natural gas, and oil—which accounted for nearly 60% of total output. Nevertheless, there has been a steady increase in the share of renewable energy sources (32.1%) and a moderate strengthening of nuclear energy's role (9.1%). This imbalance reflects the complex dynamics of the global energy transition: decarbonization is underway, but remains highly uneven across regions.

The 2024 Global Energy Mix:

- Coal — 34.5%
- Natural gas — 23.5%
- Renewable energy sources (RES) — 32.1%
- Nuclear energy — 9.1%
- Oil — 0.7%

Regional Specificities:

India maintains the world's highest coal share at 73.4%, driven by rapidly growing electricity demand. Renewables and nuclear account for only 20.5% and 2.6%, respectively.

China remains heavily reliant on coal (58.4%) but continues to expand both RES and nuclear capacity.

The United States relies primarily on natural gas (42.6%) as a transitional fuel, supplemented by RES (23.3%) and nuclear power (18%).

The European Union leads global decarbonization efforts: RES account for nearly 49% of electricity generation, with an additional 23.6% from nuclear, and only 10.7% from coal.

Key Trends:

Renewable energy is experiencing robust growth, especially within the EU. However, its expansion is constrained by generation variability and limited energy storage infrastructure.

Nuclear energy remains a stable source of low-carbon electricity, particularly attractive to countries with ambitious climate targets.

Natural gas serves as a transitional compromise, particularly in the U.S., though its long-term environmental viability is increasingly questioned.

Strategic Conclusions:

- Accelerating the energy transition requires systemic investment in RES and grid modernization.
- Nuclear energy is a key instrument for reliable decarbonization.
- Natural gas may serve as a bridging resource but cannot substitute for zero-emission solutions.
- The development of hydrogen energy and its integration with RES offers a promising model for sustainable power generation.

The global power sector in 2024 stands at a crossroads between traditional carbon-intensive paradigms and an emerging green trajectory. While coal and gas continue to dominate, the growing potential of renewables and nuclear power provides grounds for cautious optimism. The central challenge ahead is to ensure a just and technologically resilient energy transition on a global scale.

How a Trade War Could Impact Oil Demand in China and the Global Energy Market

The escalation of trade and economic tensions between China and the United States could significantly affect the global oil market. According to industry analysts, if the conflict deepens and China's economic growth slows, the increase in the country's oil demand could be halved — from 180,000 barrels per day to 90,000 barrels per day. This decline would particularly affect the diesel fuel sector, heavily used in industry and transportation, as well as the petrochemical industry, which is closely tied to exports and manufacturing supply chains.

China traditionally plays a key role as one of the largest oil consumers in the world. According to the International Energy Agency (IEA), China accounts for about 15% of global oil demand, and any fluctuations in its economy are immediately reflected in global oil prices. However, as noted by Rystad Energy, the market has recently become less sensitive to geopolitical events — including the US-Iran nuclear talks and the ongoing conflict in Ukraine. This may be due to market participants pricing in long-term volatility and reacting less sharply to individual political developments than in the past.

Nonetheless, US-China relations remain a major source of uncertainty. In particular, the potential lifting of US sanctions against certain Chinese oil refineries is under discussion, which could stimulate crude oil imports and domestic refining activity.

On the other hand, seasonal factors favor price growth. Rystad Energy forecasts that during the summer months, the price of Brent crude oil could exceed $70 per barrel, mainly driven by seasonal increases in fuel consumption. As of April, Brent prices are hovering around $67, and any positive signals from China could support further price growth.

Thus, the trade war between the United States and China acts not only as a macroeconomic challenge but also as a structural risk for the oil industry, influencing demand dynamics from the world's largest importer and refiner of oil. Amid geopolitical turbulence, China increasingly serves as a "barometer" through which market participants gauge the resilience of oil demand and the potential for future price growth.

Azerbaijan and China Sign Renewable Energy Agreement: Strategic Implications for Central Asia

The signing of a bilateral agreement between the Ministry of Energy of Azerbaijan and China Energy Engineering Corporation Limited (CEEC) in June 2025 represents a pivotal development in the energy diplomacy of the South Caucasus. Held in the Chinese city of Ningbo during the official visit of Azerbaijan's Minister of Energy Parviz Shahbazov, the agreement formalizes a comprehensive strategic partnership in the field of green energy and signals a shift in regional energy architecture with broader implications for Eurasia, including Central Asia.

The agreement encompasses multiple dimensions of renewable energy cooperation. It includes **provisions for joint electricity system planning and grid analysis, the implementation of solar, hydro, and offshore wind energy projects, and the establishment of a Joint Research Center for Green Energy**. One of the most strategic components of the agreement is the development of so-called "**green energy interconnectors**" - transnational infrastructure intended to facilitate the export and integration of renewable energy across borders.

The document outlines long-term plans for the expansion of Azerbaijan's renewable energy capacity through 2030 and beyond. Planned projects include utility-scale solar power plants in the southern regions, offshore wind farms in the Caspian Sea, and technical advisory services provided by China's EPPEI (Electric Power Planning & Engineering Institute). These services will include energy system modeling, grid integration simulations, load forecasting, and assessments of system stability and resilience.

The significance of this agreement is both practical and symbolic. For Azerbaijan, a country traditionally reliant on oil and gas exports, this partnership indicates a strategic move toward energy diversification and sustainable development. For China, it represents another step in its global strategy of exporting green infrastructure, technology, and energy planning capabilities under the Belt and Road Initiative framework.

In this context, the potential implications for Central Asia merit close attention. The region faces similar challenges: heavy dependence on conventional energy sources coupled with growing commitments to green transition and renewable integration. Countries like Uzbekistan, Kazakhstan, and Kyrgyzstan have already articulated ambitious targets for renewable energy deployment.

Azerbaijan's model of securing Chinese capital and expertise could serve as a viable blueprint for Central Asian economies seeking technological modernization in their energy sectors. Of particular interest is the knowledge-based component of the agreement - the **establishment of a joint research center and engagement of Chinese technical institutes in national grid planning**. This highlights China's role not merely as an investor, but also as a provider of analytical and institutional capacity-building. Such components could be adapted in Central Asia, where institutional frameworks for energy transition remain in development.

The geographical dimension further reinforces this dynamic. Azerbaijan's proximity to the Caspian Sea and its borders with Kazakhstan and Turkmenistan open up the possibility of future **trans-Caspian energy corridors - including "green" ones**. These could complement or even compete with existing regional initiatives such as the Central Asian Power System (CAPS), positioning China as a systemic actor in the post-Soviet renewable transformation.

Finally, it is important to situate this agreement within the broader context of the global energy transition. Countries with high solar irradiance, untapped wind potential, and small hydropower resources are emerging as critical nodes in the reconfiguration of the global energy map. Azerbaijan is among the first post-Soviet states to propose a comprehensive and technologically advanced partnership with China in this sphere. Central Asian states, if they maintain political stability and openness to international capital and technical cooperation, may replicate and adapt this approach to fit their own energy security strategies.

In conclusion, the Azerbaijan–China renewable energy agreement should be viewed not only as a national development strategy, but also as a potential accelerator of regional transformation. For Central Asia, the agreement offers a case study in integrating renewable energy, upgrading grid infrastructure, and leveraging international expertise - all essential components for a resilient and diversified energy future.

The Significance of the European Union for the Energy Stability of Central Asia

Central Asia is an important energy region with 3% of the world's oil reserves, 12% of gas, and great potential for renewable energy sources. After the start of the war in Ukraine in 2022, the EU increased its attention to the region, seeing it as a strategic partner for supply diversification and the "green" transition. As emphasized in the "EU Strategy on Central Asia," the goal is not control over resources, but support for reforms, convergence of legislation, and the implementation of environmental standards. This is being realized through the "Sustainable Energy Connections in Central Asia (2022-2026)" initiative and the "Global Gateway" program with investments of up to €12 billion in renewable energy sources, digitalization, and ecology. The EU offers a long-term partnership based on technology and sustainable development, which differs from resource-based strategies. Today, the EU is one of the region's largest economic partners: it accounts for 22.6% of foreign trade and more than 40% of foreign direct investment. In energy, its participation is expressed in investments, technological support, and the joint development of "green" solutions.

I. The EU as an investor in the energy sector of Central Asia.

The EU plays a key role in Central Asian energy, providing not only investments but also access to modern technologies and expert support. In particular, the European Bank for Reconstruction and Development acts as a leading instrument, having invested a record €2.26 billion in the region in 2024. Most of these funds were directed toward sustainable and "green" infrastructure, including the modernization of grids and the construction of renewable energy facilities. Among the countries of the region, the largest volumes of investment went to Uzbekistan and Kazakhstan. For reference: key projects include the construction of high-voltage power lines in Kazakhstan and Uzbekistan, the region's largest solar power plant with energy storage in the Tashkent region, as well as the first "green" hydrogen production project in Central Asia located in Kazakhstan. Furthermore, European companies are actively involved in the region's energy development. The Italian company Eni holds stakes in Kazakhstan's largest oil and gas projects, and the French company Orano is involved in uranium mining in Kazakhstan and Uzbekistan. France covers a significant portion of its NPP (nuclear power plant) needs with uranium from the region, and the partnership in the nuclear sphere continues to deepen. The EU plays a leading role in harmonizing energy regulations using the experience of the European Network of Transmission

System Operators for Electricity (ENTSO-E) and the integration of Balkan markets. Cooperation is conducted in the "5+EU" format and through bilateral agreements. The EU Strategy for Central Asia has been in effect since 2019, and in 2023, a Roadmap was approved with about 80 measures for the development of trade, climate, and energy. All countries in the region have joined initiatives to reduce methane and have ratified the Paris Agreement. The EU provides technical assistance for energy sector reforms, competition development, and coordination on water resource management.

II. The EU as a regulator of standards and a provider of technological solutions.

The EU exerts a noticeable influence on Central Asian energy by spreading its standards, norms, and technologies. Countries in the region, seeking to enter European markets, are adapting to these requirements — from environmental norms to market rules. An example is the EU carbon border adjustment mechanism introduced in 2023. It affects the export of energy-intensive products, including steel, cement, and electricity, and involves the calculation of a carbon fee if the products are manufactured with high greenhouse gas emissions. This creates additional pressure on producers from Central Asia and simultaneously forms incentives for the modernization of production, transition to renewable energy sources, and improvement of energy efficiency. Kazakhstan and Uzbekistan have already begun looking for ways to reduce the carbon intensity of their products, including with the help of European initiatives and technologies. For reference: In Uzbekistan, with the support of the EU and EBRD, the region's first industrial energy storage system (500 MWh) began operating. European companies such as Siemens, ABB, and Total Eren are participating in the construction of solar power plants, modernization of substations, and the transition to high-efficiency generation.

III. Balance of opportunities and challenges of energy cooperation with the EU.

Cooperation with the EU opens opportunities for Central Asia to diversify export markets — primarily by reducing the former dependence on transit routes through Russian territory and from exports to volatile or volume-limited markets such as China or Middle Eastern states. More than 70% of Kazakh oil goes to Europe; exports in 2024 amounted to more than 1 million barrels per day, making Kazakhstan the third-largest supplier to the EU. After the halt of natural uranium exports from Niger in 2023, Kazakhstan became its main supplier, covering over 40% of EU needs. This ensures stable foreign exchange earnings and long-term contracts. At the same time, direct export to Europe is limited by the lack of a common border and pipelines — oil goes through the Black Sea and transit

countries. Under these conditions, the EU's practical contribution to the region's energy development becomes especially significant: investments are directed toward infrastructure renewal, construction of power lines, and support for "green" energy projects. The EU also transfers technologies — energy-efficient equipment, digital control systems, modern turbines, and metering systems. This local approach not only strengthens the reliability of energy systems but also prepares Central Asian countries for entry into more sustainable and diverse external markets. However, Central Asia is a zone of active competition. Over the past 20 years, China has invested over $105 billion, predominantly in infrastructure projects and raw material assets; the UAE and Saudi Arabia finance renewable energy projects; Russia maintains influence through critical infrastructure — gas pipelines, power lines, and transport routes. The EU must create more flexible conditions to maintain the interest of the region's countries. Moreover, cooperation with the EU contributes to the growth of energy specialists' qualifications: more than 500 specialists from Kazakhstan, Uzbekistan, Kyrgyzstan, and Tajikistan have been trained under Erasmus+, European Commission programs, etc., as well as through partnerships with European universities and institutes. They work on developing tariff models, energy efficiency, and digital metering systems. Investments face barriers: the tariff model changed in Kazakhstan, and in Uzbekistan, there are payment delays from state companies. The international agency Fitch, which assesses the reliability of countries for investors, notes delays in obligations to investors, which required the creation of a special company that officially buys electricity from private producers — "Uzenergosotish" — and additional guarantees from international institutions.

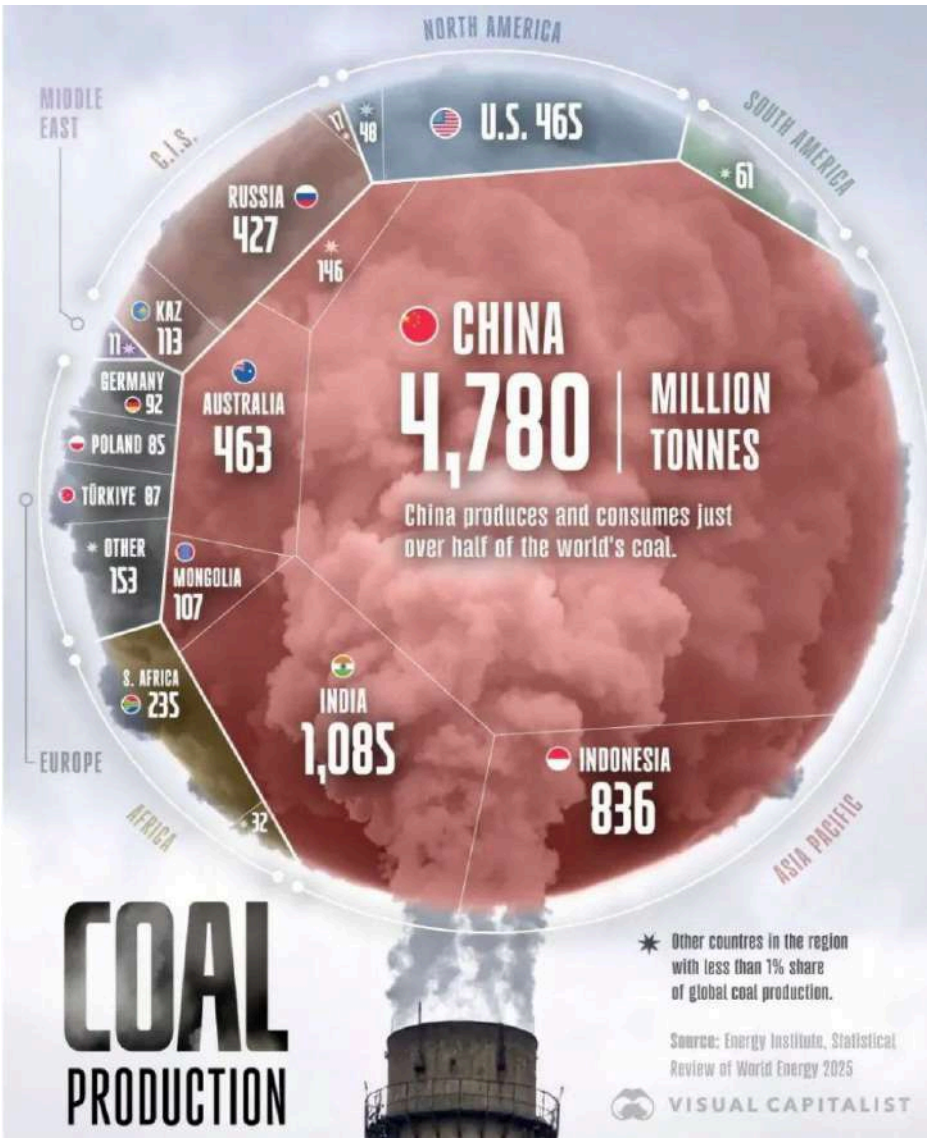
IV. Strategic priorities and directions for the development of energy cooperation with the EU.

Geopolitical changes and the reorientation of export flows enhance the importance of infrastructural connectivity between Central Asia and the EU. The Middle Corridor — a strategic transport route for sustainable logistics — acquires special significance. Kazakhstan is modernizing the ports of Aktau and Kuryk, expanding their capacity and increasing the fleet of Caspian tankers to transport oil to the port of Alat (Azerbaijan). Uzbekistan and Turkmenistan are updating the port of Turkmenbashi, creating a regional logistics hub. The China-Kyrgyzstan-Uzbekistan railway, the construction of which began in 2022, will significantly reduce transit times for energy cargoes to Europe. The Trans-Caspian Gas Pipeline between Turkmenistan and Azerbaijan will be able to supply up to 15 billion cubic meters of gas to the EU annually, expanding export opportunities and

strengthening the region's energy autonomy. To integrate with the European market, Central Asian countries need to eliminate the fragmentation of tariffs, standards, and grid management. The creation of a Central Asian Energy Community, modeled after the South East European one, will provide legal certainty and cross-border electricity trade. Overall, the potential for partnership is far from exhausted. With the successful implementation of EU initiatives and the readiness of Central Asian countries for reforms, it is possible to create a new energy space from Europe to Central Asia as an important element of global security and climate stability.

Global Coal Production: Asia as the Dominant Force

The global coal market remains highly concentrated, with the majority of production located in Asia. According to data from the Energy Institute (Statistical Review of World Energy 2025), China accounts for **4,780 million tonnes** of coal per year—more than half of global production. This makes China not only the largest producer but also the leading consumer of coal. It extracts 4.5 times more than India and nearly 10 times more than the United States. This scale is driven by China's energy structure, which still heavily relies on coal, despite massive investments in renewables.



India ranks second with **1,085 million tonnes**, driven by growing industrial and residential demand for electricity. **Indonesia**, with **836 million tonnes**, is largely export-oriented, supplying coal to Southeast Asia, China, and South Asia.

Among Western nations, **the United States (465 Mt)** and **Australia (463 Mt)** remain major producers. Despite green transition policies, both continue to maintain stable output— the U.S. primarily for domestic use, and Australia for export. **Russia** follows with **427 Mt**, maintaining its status as a key player despite sanctions and reduced exports to Europe. Regional suppliers such as **Kazakhstan (113 Mt)** and **Mongolia (107 Mt)** continue to strengthen their positions, especially in supplying China.

In Europe, countries like **Germany (92 Mt)**, **Poland (85 Mt)**, and **Turkey (87 Mt)** continue coal production despite decarbonization goals, largely driven by energy security concerns and the need to replace natural gas imports after the 2022–2023 energy crisis.

In summary, **Asia is the undisputed center of global coal production**, accounting for over 75% of output. Asian countries are now key players in the global climate agenda, and any shift in their energy policies will have a direct impact on global emissions. The future of coal largely depends on decisions made in Beijing, New Delhi, and Jakarta.

The analysis of the prospects for energy interaction between Russia and the USA in current conditions goes beyond narrow economic calculations and is substantially determined by the transformation of the global energy and political architecture. After 2022, direct ties in the oil and gas sector have been practically curtailed; however, both countries remain key actors in world energy and, through their decisions, shape the parameters of price, infrastructure, and technological restructuring.

I. The Oil Sector

Prior to the imposition of the embargo by the United States in March 2022, imports of Russian oil and petroleum products amounted to about 670,000 barrels per day, mainly heavy fractions for American refineries. The cessation of these supplies, the exit of ExxonMobil from the Sakhalin-1 project, and the loss by British Petroleum of its stake in Rosneft's capital (valued at $25 billion) signified a factual rupture of cooperation and the elimination of leading channels for the presence of American companies in the Russian oil industry. This created conditions for a transition to a stable competitive model without significant elements of complementarity.

According to the U.S. Energy Information Administration, by 2023, oil production in the USA reached an all-time high of 12.9 million barrels per day, allowing Washington to consolidate its status as one of the key global producers and exporters, including in the format of oil and LNG supplies to Europe and allies. Russia maintains production at a level of 10–11 million barrels per day, maintaining participation in the OPEC+ format and adapting its export policy to sanctions restrictions and the G7 price cap on Russian oil at $60 per barrel.

In response to sanctions and the embargo, Russia is forcedly reorienting its oil exports to Asia and the countries of the Global South—India, China, Indonesia, Vietnam, Pakistan, and states in Africa, Latin America, and the Middle East. Simultaneously, the USA, while not being an OPEC member, utilizes a combination of market and political-regulatory instruments to influence the global situation. In the medium term until 2030, a configuration is forming in which Russia establishes itself as a supplier for Asian and Southern markets, while the USA strengthens its role as a guarantor of supplies for Europe and the network of allies in the North Atlantic and beyond.

II. The Gas Sector: Redistribution of Markets and Formation of Transit Hubs

Prior to 2022, Russia provided about 40% of EU gas imports (approximately 150 billion m^3 per year), which created a stable interdependence between European demand and Russian exports. The rupture of a significant portion of long-term contracts, the undermining of the Nord Stream infrastructure, and the implementation of the "REPowerEU" program, adopted by the European Commission in 2022 and aimed at a total phase-out of Russian energy resources by 2027, led to a reduction in Russia's share of the European gas market to 10–11% (about 45–50 billion m^3 in 2024).

In parallel, the USA became the world's largest exporter of liquefied natural gas (LNG). In 2023, the volume of American LNG exports reached approximately 215 billion m^3 per year, with up to 70% of these supplies directed to Europe. American gas became one of the key elements in replacing Russian supplies and the main tool for realizing the goals of "REPowerEU." As a result, the USA strengthened its economic presence in Europe and increased its political influence, turning energy into an important structural component of the strategic partnership with the EU.

Despite the formal reduction of direct Russian gas supplies to the EU, its indirect presence persists through transit and intermediary schemes. Turkey occupies a central place in this configuration, acting as a key transit hub. Through the TurkStream pipeline with a capacity of 31.5 billion m^3 per year, gas is supplied for Turkey's needs and in transit to Bulgaria, Hungary, Serbia, and Greece. Ankara is promoting the idea of creating a gas hub that will consolidate flows from Russia, Azerbaijan, and Iran, allowing for the formation of mixed gas streams without an unambiguous fixation of their origin. According to Reuters and the European Central Securities Depository, supplies through the Strandzha-Malkoclar point on the Turkish-Bulgarian border grew after 2022, while the origin of part of the gas remains uncertain, prompting statements from the European Commission regarding the need for greater transparency along these routes. Effectively, Russia maintains a portion of its presence in the European market in an indirect format, Turkey strengthens its status as a regional energy hub, and EU countries gain an additional channel of flexibility amid a course toward diversification and reduction of dependence on Russian supplies.

III. Nuclear Energy: Technological Rivalry Against the Backdrop of Ongoing Interaction

Nuclear energy remains the only area where interaction between Russia and the USA has not been completely terminated. As of 2023, about 25% of enriched uranium for American nuclear power plants was imported from Russia, reflecting a deep technological and raw material interdependence established over previous decades. In 2024, the U.S. Congress passed the

"H.R.1042" act, providing for a phased ban on the import of Russian nuclear fuel by 2028; however, for the transition period, exemptions are maintained due to the technological dependence of part of the reactor fleet on Russian isotopes and limited alternative enrichment capacities.

Simultaneously, both countries are increasing competition in the field of new energy technologies. The USA is betting on the development of small modular reactors and the expansion of its national uranium enrichment base, including for meeting its own needs and export projects. Russia, through Rosatom, is actively promoting foreign projects for the construction and operation of nuclear power plants in Turkey, Egypt, India, Bangladesh, and other states, forming an "infrastructure-fuel-service" link and strengthening long-term political and economic influence on host countries. As a result, two technological centers of influence are emerging in the global nuclear energy market, whose decisions will determine the standards and structure of this segment in the coming decades.

Special significance is held by the participation of both countries in the largest project of its kind—the International Thermonuclear Experimental Reactor (ITER) based on hydrogen fusion in France. Thirty-five countries are involved in the project, including Russia and the USA. Despite general political tensions, Russia continues to fulfill its obligations regarding the supply of equipment and materials. The maintenance of cooperation in this project demonstrates that in critically significant scientific and technological projects, a limited format of multilateral interaction is possible, relatively resistant to political crises.

IV. Global Consequences, Redistribution of Influence, and Prospects

The restriction of direct energy ties between Russia and the USA and the sanctions pressure after 2022 have led to the formation of a new energy architecture. Instead of a simpler model based on large flows between traditional suppliers and consumers—primarily Russia and the EU—a multipolar network of routes is intensifying, in which transit and intermediary states—Turkey, Qatar, India, China, and a number of Middle Eastern countries—play a critical role.

After 2022, Russia is accelerating the diversification of its exports, shifting them from the European direction to the East and South. While before 2022 about 55% of hydrocarbon exports were accounted for by the EU, by 2025 over 75% of oil and gas is oriented toward the markets of Asia, the Middle East, and the countries of the Global South. This is driven by both sanctions restrictions and the desire to gain a foothold in fast-growing economies with predicted stable demand for energy carriers and more flexible terms for long-term contracts.

In parallel, the importance of India, China, and Middle Eastern countries is increasing. India has turned into one of the largest buyers of Russian oil: its share in Indian imports grew from less than 2% in 2021 to over 30% in 2024. Indian refineries process Russian oil, and the refined products enter the global market, including Europe, creating a hidden channel for the presence of Russian raw materials in Western markets. China is becoming the primary destination for Russian gas: supplies via the "Power of Siberia" pipeline reached 22 billion m^3 in 2024 and, according to plans, should reach 38 billion m^3 by 2027; the "Power of Siberia-2" project is under discussion, which is capable of practically doubling export volumes. In the Middle East, Russia is negotiating LNG supplies to Bahrain and is interacting with the UAE on matters of energy infrastructure; according to Reuters, discussions on long-term contracts are in an advanced stage. Thus, a stable complex of energy directions is forming in the Asian and Middle Eastern vectors, where Russia acts as a major supplier, and host countries receive additional resource sources and political-economic dividends.

For the USA, such a configuration has a dual effect. On one hand, Washington has strengthened its economic and political presence in Europe, becoming the main supplier of LNG (up to 50% of EU imports). On the other hand, the strengthening of the Russian presence in Asia and the Middle East objectively limits the possibilities for the USA to concentrate influence in these regions and increases competition for long-term contracts, infrastructure projects, and technological standards.

The global energy system is shifting from a hierarchically organized structure to a more networked configuration, in which a multitude of nodes and routes create both greater flexibility and increased vulnerability. Any disruptions on key transit routes (the Bosphorus, the Suez Canal, the Strait of Hormuz) can cause significant price fluctuations. The significance of the political stability of intermediary states (Turkey, Egypt, Qatar, etc.) is increasing substantially. Competition is shifting from the level of sales markets only to the level of technologies, investments, decarbonization standards, and the regulation of low-carbon energy.

Under these conditions, energy interaction between Russia and the USA, despite the minimization of direct contacts, remains a system-forming factor in world energy. Both countries, through their decisions, continue to determine the balance of power, set price benchmarks, and establish the framework parameters for technological development. Prospects for direct bilateral cooperation in the oil and gas sphere for the coming years appear limited and largely depend on the overall trajectory of political relations and the sanctions regime. At the same time, indirect

interaction through global markets, transit hubs, multilateral mechanisms, and scientific-technological projects will persist and exert a defining influence on the formation of the new world energy architecture.

In the context of the accelerated redrawing of Eurasia's energy map and the emergence of new geopolitical risks, the traditional model of interaction between Uzbekistan and Turkmenistan, based on gas trade under the "buyer-seller" principle, is ceasing to meet the long-term interests of both countries.

It should be noted that Uzbekistan's energy balance is undergoing a structural shift. According to the results of the first three quarters of 2024, natural gas production decreased by 4.8% to 33.48 billion m^3. The forecast of JSC "Uzbekneftegaz" for 2025 has been reduced to 26.5 billion m^3 against the previously planned 34.1 billion m^3. The reduction is associated with the depletion of mature fields ("Gazli", "Shurtan") and the rising cost of production (the need for booster compression, hydraulic fracturing, etc.).

At the same time, for the first ten months of 2024, gas imports by Uzbekistan reached $1.36 billion, increasing 2.4 times compared to the previous year. The main suppliers are Turkmenistan and the Russian Federation. Exports to China are maintained, but their scale (about $0.6 billion per year) no longer compensates for the import component.

For Turkmenistan, the picture is a mirror image. Possessing gas reserves at the level of 13.6–27.4 trillion m^3 (Galkynysh–Yashlar–Garakel cluster), the country maintains a production surplus (80–86 billion m^3 per year) but is bound by the monopsony of the Chinese market. According to estimates, 75–80% of the export flow of Turkmen gas goes to China through three active strings of the "Turkmenistan — Uzbekistan — Kazakhstan — China" pipeline. In January–November 2025, Turkmenistan's revenue from supplies to the PRC amounted to about $7.03 billion.

According to estimates, plans for the construction of the fourth string of the Chinese gas pipeline (Line D) and the implementation of the TAPI project (up to 33 billion m^3/year) remain in the negotiation stage and do not provide Turkmenistan with a guaranteed exit from the monopsony. At the same time, the Qosh Tepa canal in Afghanistan creates a long-term water risk for both states (withdrawal of up to 10–15 billion m^3 of water, which is equivalent to 20–30% of the Amu Darya flow), threatening hydroelectric power generation and increasing dependence on gas generation.

In these conditions, it is advisable to consider a transition to the format of a unified energy-technological cluster. In such a model, Uzbekistan acts not only as a buyer of gas but also as a provider of technology, services, and capital for the modernization of the Turkmen fuel and energy complex, while Turkmenistan acts as a key donor of the resource and a partner in joint projects with high added value.

2. Ensuring Physical Security and Market Balance

2.1. Gas Sector

It should be noted that an objective complementarity has formed between the two countries: Uzbekistan experiences a deficit of gas and UGS (Underground Gas Storage) capacities, while Turkmenistan faces a monopsony and limited export infrastructure. According to foreign trade data, in January–July 2025, Uzbekistan reduced gas imports by approximately 30% to $734 million, while simultaneously increasing gas exports to China by 38% to $695.6 million. This indicates that Tashkent has a certain maneuverability in partially reorienting supply directions and provides space for bilateral deals.

Proposed package of solutions:

1. **Long-term Off-take contracts based on the Netback formula.** It is advisable to conclude 5-year contracts for the supply of 4–6 billion m^3 of Turkmen gas per year to Uzbekistan. The Netback formula should link the price to quotes in target markets (South Asia, China) minus transport costs. Such a mechanism:

- provides Turkmenistan with a predictable cash flow to finance the 2nd and 3rd stages of Galkynysh (up to 25 billion m^3/year for China and up to 33 billion m^3/year via TAPI);
- allows Uzbekistan to obtain a baseline resource for the domestic market and possible re-export.

2. **"Storage as a Service" Project.** In the medium term, it is advisable to organize seasonal storage of Uzbekistan's gas in depleted reservoirs in Turkmenistan (Lebap Velayat and other promising structures). Gas injection in summer and withdrawal in winter will:

- smooth out seasonal demand peaks in Uzbekistan without resorting to spot purchases;
- create an additional paid service for the Turkmen side.

3. **"Virtual Pipelines" for enclave regions.** To ensure sustainable supply to Khorezm, Karakalpakstan, and adjacent areas of the Dashoguz region, it is advisable to apply a "virtual

pipeline" scheme — supplies of small-scale LNG/CNG by road from northern Turkmen fields. This will relieve the "Central Asia – Center" (CAC) system, which is occupied by reverse flows of Russian gas, and increase the stability of supply to the border areas.

4. **Technical Audit and Modernization of the CAC.** To minimize technogenic risks, a joint technical audit of the CAC system is necessary, including in-line diagnostics and modernization of compressor stations. Uzbekistan can utilize the resources of "Uztransgaz" and machine-building plants to modernize compressor stations on the Turkmen side in an "investment in exchange for capacity access" format.

2.2. Power Engineering and the Water Factor

According to estimates, the installed capacity of the Turkmen power system is about 6,948 MW, the vast majority of which comes from gas-fired plants. The TAP-500 (Turkmenistan – Afghanistan – Pakistan) power line project, implemented with the participation of Çalık Enerji, should ensure electricity exports to the south. In parallel, Uzbekistan is promoting the "Surkhan – Puli-Khumri" project, oriented towards power supply to Afghanistan.

At the same time, the reduction of the Amu Darya flow due to the Qosh Tepa canal creates a risk of a significant drop in hydroelectric power output in Uzbekistan and an increased need for both states for gas generation.

Proposed "Seasonal Swap" mechanism. In the context of the accelerated commissioning of RE (Renewable Energy) in Uzbekistan (Zarafshan wind farm 500 MW, Kungrad complex 1.5 GW with 300 MWh storage and 1,450 km lines, Nukus-II wind project 200 MW with 100 MWh storage, 250 MW solar station with 63 MWh storage in Bukhara), it is advisable to implement a model of mutual resource exchange:

- In summer during the day, Uzbekistan exports surplus solar and wind generation to Turkmenistan to cover cooling peaks;
- In winter and at night, Turkmenistan returns an equivalent volume in the form of electricity from gas TPPs (e.g., Mary GRES) or in the form of gas.

The reintegration of Turkmenistan into the Central Asian Power System (CAPS) and the restoration of the functions of the regional dispatch center in Tashkent will allow for the rapid balancing of flows and the integration of growing RE volumes.

3. Technological Partnership and Ecology

3.1. Exploration and Production (Upstream)

It should be noted that the "light gas" of Galkynysh is effectively contracted for China and TAPI, whereas the main growth potential is associated with deeper and more complex horizons. In these conditions, Turkmenistan is interested in partners ready to share technological and financial risks. Uzbekistan possesses relevant competencies:

- **JSC "Uzbekneftegaz"** in the field of seismic exploration and field modeling;
- **Eriell**, having a fleet of about 90 drilling rigs, experience in drilling 471 wells, and the construction of 398 km of gas pipelines;
- **SANEG**, implementing projects for the construction of over 70 km of gas pipelines and 21 compressor stations, elimination of flaring, and reduction of CO_2 emissions by 138 thousand tons/year, with an increase in gas production to 1.4 billion m^3 (2022) and targeting 3 billion m^3 by 2026.

At the same time, large international players (CNPC, Petronas, Dragon Oil) are concentrated mainly offshore or on relatively less complex objects. Petronas extended the agreement for offshore Block 1 until 2050, and Dragon Oil announced plans for investments of over $10 billion in the Cheleken asset with production growth to 447 million barrels.

Proposed mechanism:

1. Creation of a joint venture on PSA (Production Sharing Agreement) terms for the development of complex onshore blocks with the participation of Uzbekneftegaz, Eriell, and Turkmen companies.
2. Use of the production capacities of "Uzbekkhimmash" and other Uzbek machine-building enterprises for the supply of equipment to Turkmen fields and gas processing plants.
3. Supply of Uzbek pipes, cables, and metal structures for the offshore projects of Petronas and Dragon Oil, as well as for the development of the Dostluk fields (jointly with Azerbaijan) and the modernization of infrastructure in the Turkmenbashi region.

3.2. Ecology and ESG: Methane as a Resource

According to international research data, Turkmenistan remains one of the major emitters of methane: long plumes are regularly recorded over oil and gas sector facilities. At the same time, the country has gas reserves of about 400 trillion cubic feet and a production volume of more than 3 trillion cubic feet of dry gas per year, which increases attention to leakage issues.

Positive shifts have already begun. Turkmenistan joined the Global Methane Pledge initiative, achieved zero methane emissions at a number of sites (Darvaza) in November–December

2024, and set a goal to reduce emissions by 20% by 2030. Independent assessments record a reduction in emissions of approximately 10% by 2023.

It is proposed to form a joint "Green Gas" project, within which:

- A consortium is created with the participation of Uzbek structures, international technological partners (Baker Hughes, SLB), and Turkmen operators;
- Leak Detection and Repair (LDAR) systems are implemented, vapor recovery units are installed at compressor stations, and flare systems are modernized;
- Captured gas (estimated up to 4–5 billion m^3/year) is qualified as a "saved resource" and directed either to Uzbekistan at a discounted price or as payment for the consortium's services.

SANEG's experience in eliminating flaring and CO_2 emission accounting creates a basis for expanding Uzbek ESG solutions to Turkmen territory.

4. Creating Added Value and Developing New Segments

4.1. Gas Chemistry and Trading

Turkmenistan has already launched several gas chemical enterprises (Ovadan-depe, Kiyanly, Garabogaz) but faces problems with product marketing and human resources. Uzbekistan successfully implemented the large-scale Uzbekistan GTL project in Kashkadarya, accumulating experience in operating a technologically complex Gas-to-Liquid chain.

It is advisable to:

- Consider the construction of a joint gas chemical complex in the Ovadan-depe zone using MTO (methanol-to-olefins) technologies and GTL elements;
- Produce motor fuels and polymer products with high added value, reducing the share of raw gas exports;
- Create a "Unified Export Office" to coordinate supplies of sulfur, urea, gasoline, and GTL products to the markets of Turkey, South Asia, and the EU, minimizing mutual dumping and strengthening the negotiating position.

4.2. RE, Nuclear, and Hydrogen

In Uzbekistan, by 2026, it is planned to commission up to 8 GW of RE, and by 2030 — up to 12 GW with a share of 25–40% in the power balance. Projects with Masdar and ACWA Power are being implemented, including wind farms with large storage systems. According to IFC and ADB

estimates, a 250 MW solar station with 63 MWh storage in Bukhara will provide electricity for up to 75 thousand households and reduce CO_2 emissions by 327 thousand tons per year.

In Turkmenistan, pilot projects are currently being implemented: a 10 MW hybrid wind-solar installation and a planned 100 MW solar station with the participation of Masdar.

In the nuclear sphere, Uzbekistan and NMMC (Navoi Mining and Metallurgical Company) have experience in mining about 3,500 tons of uranium per year using the in-situ leaching method and implementing bacterial technologies that increase the recovery factor 2.4 times. The construction of a low-power NPP (six RITM-200N reactors with a total capacity of 330 MW) is planned by 2029.

Taking these factors into account, it is proposed to:

- Implement a "Gas-to-Export" model through the construction of RE capacities by Uzbek developers in Turkmenistan with the subsequent release of gas for export;
- Offer Turkmenistan a transfer of NMMC technologies for in-situ and bacterial leaching of uranium, and organize the training of Turkmen personnel at Tashkent universities;
- Develop a joint "Hydrogen Roadmap", including pilot projects for "blue" hydrogen (gas + CCS) and "green" hydrogen (electrolysis on RE), as well as the creation of a cluster for the production of ammonia/hydrogen for export to the EU and mixing 5–10% hydrogen into gas pipelines.

5. Institutional Conditions and Security

5.1. Digitalization and Clearing

It should be noted that the opacity of accounting and differences in metrology are sources of distrust and disputed situations. To minimize them, it is advisable to:

- Implement unified SCADA and AISCE (Automated Information and Sales Control System for Electricity) systems at all cross-border gas and electricity transfer points;
- Use smart metering devices providing real-time data exchange;
- Unify standards for caloric value, sulfur content, and other gas parameters.

To reduce currency risks and take into account the limitations of the Turkmen financial system, it is advisable to develop clearing mechanisms in the "Shavat–Dashoguz" border trade zone, using barter schemes (gas against industrial and consumer products).

5.2. Infrastructure Security and Emergency Mutual Assistance

Long pipelines and power lines pass through sparsely populated desert areas, and the proximity of Afghanistan increases the risk of sabotage and unauthorized tapping. The experience of the January 2022 blackout showed the scale of possible cascading failures.

It is recommended to:

- Use Uzbek unmanned systems (UAV "Lochin", developed by the State Committee for Defense Industry) for round-the-clock monitoring of main pipelines, power lines, and hub facilities;
- Create a joint Situational Response Center with automatic processing of data from drone patrols and dispatch systems;
- Establish an emergency mutual assistance protocol, providing for a "hot reserve" of TPP capacity in Uzbekistan and reserve gas volumes in Turkmenistan with automatic activation during emergencies.

When implementing these measures, it is important to consider the specifics of decision-making in Turkmenistan (centralization of power, the role of "Turkmengas", the Deputy Prime Minister for the fuel and energy complex, as well as the influence of informal groups). An effective model must combine interstate agreements at the highest level and professional dialogue between technocratic teams.

6. Conclusions and Proposals

The analysis performed shows that the inertial scenario of relationship development with Turkmenistan increases strategic risks for Uzbekistan: dependence on Russian gas, China's price dictates, water deficits, and threats of cascading accidents. At the same time, the convergence of interests in gas, electricity, RE, and the environmental agenda creates opportunities for forming a Unified Energy Confederation of the two countries.

The study of the current situation allows for the identification of the following areas of practical work:

1. **Gas and UGS.** Transition from spot purchases to 5-year off-take contracts of 4–6 billion m^3/year based on the Netback formula, implement the "Storage as a Service" project on the basis of Turkmen depleted fields, and introduce "virtual pipelines" for LNG/CNG for dead-end zones.
2. **Upstream and Service.** Create joint ventures between Uzbekneftegaz, Eriell, SANEG, and Turkmen structures for the development of deep horizons of Galkynysh and other complex blocks; localize the repair of turbines and compressors at Navoi and "Uzbekkhimmash" plants, extending Uzbek service to the projects of CNPC, Petronas, Dragon Oil, and Çalık Enerji.

3. **Power Engineering and CAPS.** Implement the "Seasonal Swap" model (exchange of solar and gas generation), accelerate the reintegration of Turkmenistan into CAPS, and link the TAP-500 and "Surkhan – Puli-Khumri" projects with the formation of a common capacity reserve market.

4. **ESG and Methane.** Launch a joint "Green Gas" project for methane capture in Turkmenistan involving Baker Hughes and SLB technologies; use SANEG's experience, linking part of the "saved" gas with supplies to Uzbekistan.

5. **Gas Chemistry, RE, Nuclear, and Hydrogen.** Form a gas chemical cluster (MTO and GTL) based on Ovadan-depe in partnership with Uzbekistan GTL; implement the "Gas-to-Export" model for RE; promote the transfer of NMMC technologies in the uranium sphere and approve a joint hydrogen roadmap with a pilot ammonia/hydrogen cluster.

6. **Institutional Synergy and Security.** Implement unified SCADA/AISCE systems and a clearing mechanism for the "Shavat–Dashoguz" zone; deploy drone monitoring of main infrastructure; create a Situational Center and an emergency mutual assistance protocol with a "hot reserve" mechanism for capacities and gas.

The implementation of these steps will allow for a transition from a narrow trade model to a joint energy-technological cluster, strengthening the energy independence and stability of both countries in the face of external challenges.

The energy factor in Turkmenistan's foreign policy

Introduction

In recent years, Turkmenistan has sought to make changes to its foreign policy under the influence of the importance of a fundamental transformation of its foreign energy policy. In the context of the global energy transition, increased competition in gas markets, and changes in the geopolitical configuration of Eurasia, Ashgabat seeks to diversify export destinations and modernize its energy strategy. The presented material analyzes Ashgabat's foreign policy through the prism of the key vectors of Turkmenistan's foreign energy policy, analyzing the opportunities and limitations of realizing national interests in the conditions of the transforming architecture of global energy security.

Main Part

Analysis of the energy agenda in Turkmenistan allows for the identification of the following trends influencing the foreign policy of this country.

- Turkmenistan's foreign energy policy is formed under conditions of a high degree of centralization in decision-making and limited transparency of economic information. The state concern "Turkmengaz" controls the entire gas industry, including production, transportation, and export. According to estimates by the Oxford Institute for Energy Studies, the lack of independent regulators, the underdevelopment of the private sector, and limited access to international financial markets create structural barriers to the modernization of the energy sector.
- The principle of permanent neutrality, enshrined by a UN General Assembly resolution in 1995 and reaffirmed in 2015, serves as the basis of Turkmenistan's foreign policy doctrine, including energy diplomacy. Neutrality allows Ashgabat to avoid participation in regional military-political blocs, but simultaneously limits the possibilities of attracting strategic partners to protect energy infrastructure and ensure the security of export routes.
- A significant challenge remains the limited inflow of foreign direct investment (FDI). According to UNCTAD data, the accumulated volume of FDI in Turkmenistan in 2023 amounted to $42.9 billion, which is significantly inferior to Kazakhstan ($157.2 billion) despite comparable

energy resources. The main investors are China, Turkey, and the UAE, while European and American companies are practically absent from the Turkmen energy market.

- China is the dominant partner of Turkmenistan in the energy sphere. According to data for the first quarter of 2024, the trade turnover between Ashgabat and Beijing amounted to about $2.6 billion, of which 92.7% accounted for the export of Turkmen gas. According to Eurasianet estimates, in the first quarter of 2024, Turkmenistan earned about $2.4 billion from gas exports to China, which exceeded Russia's revenues from gas exports to Europe during the same period (about $2 billion). The "Turkmenistan - Uzbekistan - Kazakhstan - China" pipeline system includes three parallel lines (Lines A, B, and C) with a total capacity of 55 billion cubic meters per year. According to Eurasianet, in the first half of 2024, about 21-23 billion cubic meters of Turkmen gas was exported through this system. In 2023, Turkmenistan exported a record 40 billion cubic meters to China, which accounted for about $9.6 billion out of the total export revenue of $14.17 billion. Thus, China accounts for 75-85% of all Turkmenistan's gas exports. A key issue remains the construction of the fourth pipeline line (Line D), which is to pass through the territory of Kyrgyzstan and Tajikistan with an outlet to the western regions of China. According to S&P Global Commodity Insights, the design capacity of Line D is 30 billion cubic meters per year, which will increase the total capacity of the system to 85 billion cubic meters per year. However, the implementation of the project faces a number of challenges, including difficult mountain terrain, geopolitical risks, and the need for significant capital investment. A critical analysis of this situation shows that a monopsony, or "one buyer, many sellers," in relations with China creates structural risks for Turkmenistan's economic security. As noted in the Coface report, as of early 2024, the volume of Turkmenistan's public debt to China is estimated in the range of $8 to $10 billion, which is about 15-18% of the country's GDP. The concentration of more than 80% of exports in one direction makes Turkmenistan vulnerable to changes in China's pricing policy and demand.
- The Turkmenistan-Afghanistan-Pakistan-India (TAPI) gas pipeline with a capacity of 33 billion cubic meters per year is considered by Ashgabat as a key tool for diversifying export destinations. The project provides for the transportation of Turkmen gas over a distance of 1814 km, of which 816 km will pass through the territory of Afghanistan. The gas distribution is planned as follows: 42% for Pakistan, 42% for India, and 16% for Afghanistan. On September 11, 2024, a ceremony was held to resume work on the Afghan section of the gas pipeline on the border of Turkmenistan and Afghanistan in the Serhetabat-Herat area. The event was attended by the

President of Turkmenistan Serdar Berdimuhamedov and the acting Prime Minister of Afghanistan Hasan Akhund. As of January 2025, only 3 km of the Afghan section has been completed. At the same time, according to information published in October 2025, the Afghan part should be completed by the end of 2026. However, the implementation of the project faces significant obstacles. Firstly, there is a lack of participation from India and Pakistan in the current construction phase. According to Pakistani experts, the project becomes unprofitable without the participation of the main consumers. India has not confirmed its participation in the project, and Pakistan faces financial difficulties and cannot guarantee the payment of transit fees, estimated at $500 million annually. Secondly, there are serious security risks. Afghanistan under Taliban rule remains a zone of political instability, which poses threats to the functioning of the pipeline infrastructure. Thirdly, there are technical difficulties; in particular, the construction of 816 km of pipeline through the mountainous terrain and deserts of Afghanistan requires significant investment and technological solutions. According to the Jamestown Foundation estimate, without the full participation of India and Pakistan, the TAPI project risks remaining unrealized, which would mean the collapse of Turkmenistan's 30-year ambitions to enter South Asian markets.

- The idea of constructing an undersea gas pipeline across the Caspian Sea from Turkmenistan to Azerbaijan with further integration into the Southern Gas Corridor (South Caucasus Pipeline, TANAP, TAP) has been discussed since the mid-1990s. In 2024-2025, against the backdrop of the European energy crisis and the EU's desire to diversify gas supplies, interest in the project increased. In February 2024, Turkey and Turkmenistan signed a memorandum of understanding on natural gas supplies, providing for a swap scheme through Iranian territory with a volume of 1.5 billion cubic meters per year at the initial stage. This step is seen as an intermediate solution until the possible implementation of the Trans-Caspian project. In May 2024, Turkish Energy Minister Alparslan Bayraktar and Azerbaijani Economy Minister Mikayil Jabbarov signed an agreement on cooperation in the gas sector. Azerbaijan, which exported 11.5 billion cubic meters of gas to Europe via the Southern Gas Corridor in 2023, is considering the possibility of transiting Turkmen gas subject to technical and commercial feasibility. Nevertheless, the implementation of the Trans-Caspian gas pipeline faces several obstacles. Firstly, significant capital investments are required (estimates vary from $5 to $10 billion) in the context of reduced international financing for fossil fuels. Secondly, disagreements persist over the legal status of the Caspian Sea: Russia and Iran oppose the construction of undersea infrastructure without the consensus of all Caspian littoral

states. Thirdly, European consumers, who are forcing the decarbonization of the economy, may not guarantee long-term contracts for the purchase of Turkmen gas, which reduces the investment attractiveness of the project.

- Along with the main export destinations (China, TAPI, Europe), Turkmenistan is developing regional energy cooperation. In 2023, Ashgabat resumed gas supplies to Russia in the amount of about 5-6 billion cubic meters, when Moscow used Turkmen gas for supplies to the southern regions of Russia. However, the company "Turkmengaz" stopped exporting natural gas to Russia at the end of 2024 due to unresolved disagreements over price parameters. Official statements from the Turkmen side emphasize that the key condition for the start, continuation, or termination of supplies is exclusively the commercial component of the contracts. This logic of action indicates the pragmatization of Ashgabat's foreign economic strategy, in which priority is given to maximizing economic benefit, while political considerations are deliberately pushed into the background. In July 2024, Turkmenistan and Iran signed a contract for the export of an additional 10 billion cubic meters of Turkmen gas per year, which Iran plans to redirect to Iraq and Turkey via a swap scheme. It is expected that in the future, the volume of cooperation could reach 40 billion cubic meters per year. This scheme allows Turkmenistan to diversify export channels without building new pipelines by using Iranian gas transportation infrastructure.
- According to British Petroleum and the international association Cedigaz, Turkmenistan's proven natural gas reserves are estimated in the range of 13.6 to 19.5 trillion cubic meters, placing the country fourth in the world after Russia, Iran, and Qatar. The largest field is Galkynysh (formerly South Yolotan), with reserves estimated between 13.6 and 27.4 trillion cubic meters. According to Asian Development Bank estimates, in 2024, natural gas production in Turkmenistan amounted to about 80-85 billion cubic meters. At the same time, according to the 2024 Oxford Institute for Energy Studies report, Turkmenistan faces several structural challenges. In particular, the country is the world's third-largest source of methane emissions into the atmosphere. According to the 2025 UNECE Policy Brief, CO2 emissions in Turkmenistan in 2022 amounted to 63,655 kilotons, while the carbon intensity of the economy is 152% higher than the world average. The energy sector provides 86.3% of all the country's greenhouse gases, and natural gas accounts for 88.2% of the energy consumption structure.
- Turkmenistan's accession to the Global Methane Pledge at the COP28 conference in November 2023 marks a new stage in the country's foreign energy policy. In 2023-2024, the

government approved a "roadmap" for reducing methane emissions, which is a response to international pressure and the need to comply with climate standards for access to European and Asian markets. Within the framework of the State Program for Energy Saving (2018-2024) and the Concept for the Development of the Altyn Asyr Lake Region (2019-2025), Turkmenistan has launched pilot projects in the field of renewable energy. In 2024, the construction of a 10 MW hybrid solar-wind power plant was completed in the Balkan velayat. There are plans to build a 100 MW solar station in cooperation with the company Masdar (UAE). The integration of the climate agenda into Turkmenistan's foreign energy policy creates new opportunities for international cooperation. The UNDP and UNECE program "Support for Renewable Energy Policy Development in Turkmenistan" provides technical assistance in developing the regulatory framework and attracting investment in "green" energy. The European Bank for Reconstruction and Development (EBRD) forecasts Turkmenistan's GDP growth at 6.3% in 2024-2025, provided the economy is diversified and energy efficiency is increased.

Conclusion

The energy factor remains a central element of Turkmenistan's foreign policy, determining the architecture of its international relations and economic strategy. In the conditions of global energy transformation, the country faces the need to balance between maintaining the dominant role of gas exports and adapting to the requirements of the climate agenda and decarbonization. The critical analysis of current trends shows that successful diversification of export destinations requires a comprehensive approach, including not only the development of infrastructure projects but also institutional reforms, increased transparency, and the attraction of foreign direct investment, including through integration into international climate initiatives. However, the implementation of these tasks faces significant institutional, financial, and geopolitical limitations. Therefore, the prospects for Turkmenistan's energy diplomacy will depend on the ability of the country's leadership to create favorable conditions for international cooperation, reduce structural dependence on the Chinese market, and effectively integrate the country into regional and global energy architectures.

Uzbekistan is in a position to develop a number of initiatives to assist in solving the tasks facing Turkmenistan. The interest in cooperation with Turkmenistan lies in the fact that Uzbekistan is able to cover the objectively existing gas deficit against the background of increasing air pollution. In general, Turkmenistan is important for our country as a potential source of gas imports to cover

growing domestic consumption and energy security. In particular, it is proposed to consider the expediency of:

- **First**, initiating the development of a long-term intergovernmental contract for natural gas supplies with a flexible price formula tied to regional and world energy indices, which will allow Turkmenistan to guarantee stable export revenues and enable Uzbekistan to ensure the predictability of energy supply in the conditions of growing domestic consumption;
- **Second**, proposing, as a separate direction, the creation of a joint Uzbek-Turkmen gas consortium to coordinate supply volumes, modernize infrastructure, and attract international financing, including resources from Asian and Middle Eastern financial institutions;
- **Third**, Uzbekistan acting with an initiative for the joint modernization of gas transportation infrastructure and compressor stations in border areas, which will increase the technological reliability of transit, reduce losses, and create new jobs;
- **Fourth**, taking the environmental agenda into account, proposing a program to reduce the carbon footprint of the gas industry, including the attraction of grant funds, through the introduction of methane capture technologies, digital leak monitoring, and energy-efficient solutions at production and transportation facilities;
- **Fifth**, initiating joint projects in gas chemistry, involving the creation of facilities for processing Turkmen gas in border areas within special economic zones, which will allow Ashgabat to increase the added value of its gas and allow Uzbekistan to develop its own industrial potential;
- **Sixth**, proposing, within the framework of energy diplomacy, the initiative of forming a regional gas balance for Central Asia, where Turkmenistan will play the role of the key exporter and Uzbekistan the role of the coordinator of flow distribution, taking into account the interests of neighboring countries.

Collectively, these initiatives will allow Uzbekistan to transition Turkmenistan from the status of a simple source of gas imports for covering our country's growing domestic demand into a strategic partner in forming a sustainable and environmentally-oriented energy model for the New Central Asia.

Analytical Note on the Impact of the US–China Trade War on the Global Energy Market: Strategic Implications and Recommendations for the Republic of Uzbekistan

Section 1: Summary and Strategic Forecast for Uzbekistan

1.1. Overview of Key Changes

This analytical note provides an assessment of the consequences of the trade war between the United States and China for the global energy market in 2025. The analysis identifies a fundamental shift in the global energy paradigm: a market previously defined by concerns over supply shortages is now facing a demand-side crisis triggered by the escalation of the trade conflict.

This shift has generated five key trends:

1. **Oil demand collapse** and a strategic pivot by OPEC+ toward defending market share, leading to oversupply and falling prices.
2. **Intensification of the "resource war"** for control over critical minerals and technologies, within which China has introduced export restrictions.
3. **Acceleration of the global "green" transition** due to market saturation and a price crash for Chinese renewable energy (RE) equipment caused by US protectionist measures.
4. **Geopolitical reconfiguration in Central Asia**, which has turned into an arena for competition between infrastructure projects (China's "Belt and Road" vs. Western and regional initiatives).
5. **Acceleration of a "nuclear renaissance"** in the region, where Uzbekistan and Kazakhstan view nuclear power as the foundation of long-term security, strengthening technological partnerships with Rosatom.

1.2. Strategic Risks and Opportunities for Uzbekistan

For the Republic of Uzbekistan, the current situation presents a strategic paradox.

- **Opportunities** lie in an accelerated and economically beneficial "green" transformation; attracting investment into the critical minerals sector amid a global search for alternatives to China; and strengthening its status as a Eurasian transit hub thanks to the intensification of transport corridor construction.

- **Risks** are associated with economic pressure on key partners (Russia, Kazakhstan) due to the global downturn; the emergence of long-term geopolitical dependence in the nuclear sphere on a single technological partner; and the vulnerability of high-tech sectors due to the disruption of global supply chains.

1.3. Synopsis of Policy Recommendations

1. **Aggressively capitalize on the "resource war":** Create an inter-agency task force for the accelerated attraction of investment in the extraction and processing of critical minerals, while simultaneously utilizing low prices for state procurement of RE equipment.

2. **Prioritize the development of a "triple land connectivity" strategy:** Position Uzbekistan as an indispensable logistics hub of Eurasia, supplementing physical infrastructure construction with investments in "soft infrastructure" (customs digitalization, modern warehousing).

3. **Proactively manage geopolitical risks of nuclear partnership:** Enhance diplomatic engagement with the US, EU, and IAEA, presenting cooperation with Rosatom as a pragmatic choice for decarbonization, and actively attract Western expertise in related fields (nuclear safety, personnel training).

4. **Double down on energy efficiency and gas sector reform:** Accelerate the implementation of national energy-saving programs and continue reforms in the domestic gas market to attract investment in new production, which is critical for ensuring energy security during the transition period.

Section 2: Global Macro-Energy Environment: A Paradigm Shift

The second quarter of 2025 became a period of radical risk reassessment in the global energy market. The escalation of the US–China trade confrontation into full-scale economic warfare triggered a tectonic shift from fears of supply shortages to the certainty of a looming demand crisis.

2.1. Oil Market Shock: From Shortage Fear to Demand Collapse

Turbulence in the trade relations of the world’s two largest economies, peaking in April 2025 with mutual tariffs up to 145% and a fragile "pause" in May, led to a dramatic reversal in the oil market.

- **Sharp reduction in demand forecasts:** In its July report, the IEA presented a staggering revision. Global oil demand growth in 2025 is now expected at just 700,000 barrels per day—the lowest since 2009 (excluding the anomaly of 2020).

- **Price crash and OPEC+ strategic pivot:** Brent crude collapsed from nearly $80 per barrel at the start of the year to $64 by late May. OPEC+ pivoted from cutting production to increasing it on July 5 to protect market share.
- **Surplus formation:** Rising global production and inventory build-up, especially in China and the US, confirm a structural surplus.

2.2. Natural Gas and Coal: Divergent Regional Pressure

The gas market in Europe remained stable, with TTF prices between €33–35/MWh. Meanwhile, the EU showed a pragmatic approach by granting Kazakhstan a conditional exemption for coal transit through sanctioned Russian ports.

Section 3: Intensification of the "Resource War": Critical Minerals and Tech

3.1. Chinese Export Controls and Global Reaction

Beijing has systematically introduced export controls on tungsten, indium, seven heavy rare earth metals, and battery technologies. Gallium and germanium prices soared by 41% and 98% respectively since early 2024. This global race for non-Chinese sources opens strategic opportunities for resource-rich Central Asian countries.

3.2. Oversaturation of RE Technology Market

US tariffs closed the American market to Chinese solar panels, leading to massive overproduction and a crash in global prices. The cost of LFP battery storage has decreased by 75% over 15 years. This environment is a major advantage for Uzbekistan’s ambitious RE program.

Section 4: Central Asia at the Crossroads of Competing Visions

4.1. Regional Economic Outlook and Infrastructure "Great Game"

The IMF raised the region's 2025 growth forecast to 3.4%, with Uzbekistan expected to maintain a high dynamic of 5.9%.

- **China–Kyrgyzstan–Uzbekistan (CKU) Railway:** Moved to "full-scale construction" in Kyrgyzstan.
- **CASA-1000:** Accelerating following May 2025 agreements.
- **Caspian Green Energy Corridor:** Uzbekistan, Azerbaijan, and Kazakhstan established the "Green Corridor Alliance" in July 2025 for green electricity exports to Europe.

4.2. Reconfiguration of Regional Gas Flows

The informal "gas union" of Russia, Kazakhstan, and Uzbekistan is strengthening; Uzbekistan plans to increase Russian gas imports to 7.3 billion cubic meters in 2025.

Table 2: Status of Key Regional Infrastructure Projects (July 2025)

(Summarized from text): CKU Railway is in full construction; CASA-1000 is accelerating despite Afghan risks; Green Corridor Alliance JV is formed.

Section 5: Nuclear Renaissance: Geopolitics and Long-term Security

- **Uzbekistan:** The Rosatom project has expanded to include both a large NPP and a Small Modular Reactor (SMR) plant (6 x 55 MW). SMR construction begins Summer 2025.
- **Kazakhstan:** Selected Rosatom in June 2025 to lead an international consortium for its first NPP (2.4 GW).

Section 6: In-depth Analysis for Uzbekistan: Navigating the New Reality

6.1. National Energy Balance (H1 2025)

- **Fossil Fuel Decline:** Natural gas production fell 3.1% (21.79 bcm); oil/condensate fell 11.2%.
- **Green Energy Explosion:** By July 2025, solar and wind produced >5 billion kWh (exceeding all of 2024). RE share reached 20.3% of total generation.

6.2. Table 3: Key Energy and Economic Indicators (Update 2024–2025)

(Key highlights): GDP growth 5.9%–6.7%; Gas production ~42 bcm (forecast); RE generation >10 TWh (forecast).

6.3. Policy Implications (Detailed)

- Aggressively capitalize on the duality of the "resource war."
- Elevate the "triple land connectivity" strategy to a national priority.
- Proactively manage geopolitical risks of the nuclear partnership.
- Double down on internal energy efficiency and gas sector reforms.

Transformation of Uzbekistan's Energy System: Lessons from Hungary and Recommendations

Uzbekistan's energy system is currently in a phase of structural transition. The country aims to meet the growing electricity needs of its economy and population, reduce dependence on fossil fuels, and strengthen energy security. Currently, approximately 85% of electricity is produced at thermal power plants (TPPs) operating on natural gas, about 10% comes from hydropower, and only 5% from solar and wind sources. At the same time, recent years have seen power shortages, aging infrastructure, and high network losses.

Against the backdrop of these challenges, Uzbekistan has embarked on a large-scale modernization of the sector: constructing new combined-cycle gas turbine (CCGT) units, developing renewable energy sources (RES), and preparing for the introduction of nuclear energy in cooperation with Rosatom. In this context, the experience of Hungary—which has navigated the path of balancing energy, diversification, and integration into the European energy system—is of significant interest.

The Hungarian Model: Balanced Energy and Pragmatism

According to the Hungarian Ministry of Energy, 74% of the country's electricity is generated from clean sources:

- **42%** – Nuclear energy (Paks NPP).
- **32%** – Renewable sources (primarily solar energy).

The key to Hungary's success is the combination of baseload and green generation. "Paks" ensures system stability, while the rapid development of decentralized solar installations (over 300,000 domestic solar power plants) creates resilience and public involvement. Hungary opted for a pragmatic balance where the "green transition" does not undermine industrial competitiveness. A crucial element was the modernization of grids and energy storage systems; without this, the growth of RES led to overloads and "bottlenecks".

Nuclear Energy and Institutional Independence

Hungary's experience in the nuclear sphere is particularly relevant for Uzbekistan as it prepares to build its first NPP. The Hungarian Paks NPP is the cornerstone of the national energy system: four VVER-440 units generate about 42% of the electricity. Currently, the "Paks-2" project with two VVER-1200 units is being implemented, which will ensure long-term energy stability.

It is especially important to note that the Hungarian Atomic Energy Authority is accountable only to the Parliament, which guarantees transparency and safety. Furthermore, energy security issues are based on a goal-oriented regulatory model—focusing on final safety indicators rather than rigid procedural prescriptions. Public support for nuclear energy was built on the development of physics and technical education and the openness of nuclear facilities to society. For Uzbekistan, where a stable culture of perceiving nuclear energy has not yet been formed, this approach is vital: it is necessary to pre-establish the social, educational, and institutional foundations for safe and acceptable industry development.

Decentralization and Gas Storage

Hungary has become one of the EU leaders in the rate of solar capacity commissioning (8 GW by 2025), focusing on small-scale generation. This path is useful for Uzbekistan, where solar potential is among the highest in the world, but the energy sector remains centralized. When planning the connection of RES generation facilities, it is recommended to avoid centralization and emphasize local generation, as well as to create a system of local energy communities where municipalities and households participate in the production and sale of electricity.

Hungary is actively diversifying its energy imports and exports, managing the region's largest underground gas storage facilities (4.4 billion m^3) and participating in projects like "Shah Deniz" in Azerbaijan (MVM CEEnergy Zrt purchased a 5% stake in this project). For Uzbekistan, this is a signal of the need to increase gas storage capacity to enhance resilience to seasonal fluctuations and to consider participation in trans-regional projects connecting Uzbekistan with China, the South Caucasus, and Europe.

Strategic Planning and Human Capital

Hungary demonstrates that energy system resilience is ensured by institutional independence and long-term planning. Energy decisions are made with reliance on national institutions (MVM, Energy Strategy Institute, HIIA, Climate Policy Institute) that possess strategic and analytical functions. Based on Hungary's experience, it is recommended to:

- Strengthen the independence of regulatory bodies, particularly the Atomic Agency and the Ministry of Energy, through parliamentary oversight.
- Create an inter-agency Center for Energy Modeling and Forecasting to develop energy balance scenarios for 30–40 years.

- Increase the role of academic expertise and think tanks in energy policy formulation, following the example of the Hungarian HIIA and MCC Climate Policy Institute.

One of the most significant areas of cooperation between Hungary and Uzbekistan will be the proposal to send students and engineers to Hungarian universities and research centers, including those focused on nuclear energy and energy management. This will help implement a state program for training personnel for NPPs, RES, and grid energy based on Hungarian universities (such as the Budapest University of Technology). This serves as a reasoned and objective alternative to Russian technical universities, which will also allow for the objectification of the NPP management process in the future.

Hungarian experience shows: 21st-century energy security is not just about technology, but also about manageability, education, and public trust. These elements should become the foundation for a sustainable and competitive energy sector in Uzbekistan.

The C5+1 format, uniting the countries of Central Asia and the United States, is gradually transforming from a diplomatic mechanism for political dialogue into a practical platform for economic, technological, and energy partnerships. In the context of the accelerating global energy transition and intensifying geopolitical competition for resources and supply routes, the C5+1 platform is gaining new strategic significance. Central Asia is becoming a key link in the new architecture of Eurasian energy security, possessing vast reserves of natural gas, uranium, rare earth elements, and solar energy. The United States, in turn, possesses the technological, financial, and institutional potential capable of transforming this regional resource potential into sustainable and diversified development.

The strategic C5+1 format is no longer just a diplomatic venue between the US and Central Asian countries. Given the changing geopolitical reality, the energy transition, and growing competition for transit routes, the platform must evolve into an "C5+1+ extended format," including the South Caucasus and Afghanistan, forming a new strategic arc from the Caspian Sea to the Indian Ocean. This format will become an integration framework for energy, logistics, critical minerals, and innovative technologies, where the US acts not only as an investor but also as a partner for the transfer of knowledge and technology, and the countries of the region act as equal co-authors of industrial and infrastructural solutions.

The strategic goal of the expanded C5+1 platform is to create a single, technologically integrated space in Eurasia, where Central Asia, the South Caucasus, and Afghanistan are connected by sustainable energy, logistics, and digital corridors, and the US becomes a guarantor of the region's technological and investment development, based on the following principles:

1. **Transfer of technologies and know-how**, rather than the export of raw materials;
2. **Localization of production** and the development of high-value-added industry;
3. **Balanced economic partnership**, beneficial for both the region and the US;
4. **Inclusion of Afghanistan and the South Caucasus** into energy and transport routes as an element of long-term stability.

The development of these areas will allow the C5+1 to turn into a regional mechanism for the practical implementation of US "soft power" and resource diplomacy, where Uzbekistan can act as a key center of attraction for technological and investment flows.

1. Joint program for the modernization of gas infrastructure and reduction of leaks.

The gas infrastructure of Central Asia remains a key element of energy security, but its significant deterioration leads to gas losses and high methane emissions. The United States possesses the world's best methane monitoring, compression, and utilization technologies, which can serve as the basis for creating a regional center for low-carbon technologies in Uzbekistan.

Goal of cooperation: Creation of a modern, energy-efficient, and environmentally sustainable gas infrastructure in Uzbekistan through the introduction of American methane monitoring, compression, and leak utilization technologies.

Proposals:

1. Develop a **C5+1 Regional Methane Initiative**, including Uzbekistan, Kazakhstan, Turkmenistan, and Azerbaijan, with the participation of US companies (e.g., Honeywell, ExxonMobil, Baker Hughes).
2. Establish an **Engineering and Training Center for Gas Infrastructure** in Uzbekistan, where American and Uzbek specialists jointly train personnel and adapt technologies to local conditions.
3. Utilize the potential of the **DFC** (Development Finance Corporation) and **DOE** (Department of Energy) to finance the modernization of compressor stations and the digitalization of networks.

The implementation of this area of cooperation creates mutual benefits for all participants:

- **For Uzbekistan**, this means increasing energy efficiency through infrastructure modernization, gaining direct access to modern American technologies and know-how, developing new professional competencies, and the possibility of exporting engineering and technical services.
- **For the US**, it means expanding access to the dynamically developing energy technology market of Central Asia, strengthening its technological presence in the region, and promoting its own standards of sustainable development.
- **For the region as a whole**, cooperation will bring a reduction in harmful emissions, deeper energy integration, and increased supply reliability, creating a basis for the formation of a sustainable and interdependent energy architecture in Eurasia.

Justification:

- **Technical:** The US possesses advanced solutions in methane leak detection, digital pipeline management, carbon capture, and energy-efficient compressor technologies, which will significantly reduce gas losses and greenhouse gas emissions.
- **Financial:** The participation of American companies (with the support of DFC, DOE) will create the opportunity to attract low-cost financing and direct investment, reducing the burden on the budget.
- **Geopolitical:** Traditionally, Russian companies are active in the gas infrastructure modernization sector; however, involving the US will allow for the diversification of partners, reduction of technological dependence, and strengthening of Uzbekistan's energy sovereignty.

2. National audit of critical minerals and creation of a technological resource map.

The region possesses enormous potential in lithium-containing, cobalt, rare earth, and uranium resources, but without their own processing, countries remain at the raw material level. The US, in need of reliable supplies of critical minerals, is interested in developing the full chain—from exploration to processing and finished products.

Goal of cooperation: Development of a complete and transparent database of Uzbekistan's critical minerals (lithium, cobalt, titanium, rare earth elements) with the participation of the USGS (U.S. Geological Survey) and American geotechnological companies.

Proposals:

1. Create a **C5+1+ Mining and Minerals Technology Partnership** with the participation of the USGS, DOE, and leading American universities (MIT, Colorado School of Mines) for training, mapping, and implementing processing technologies.
2. Form a **regional cluster for the processing of lithium and rare earths** in Uzbekistan with partially localized production of batteries, magnets, and components for RES and electrical engineering.
3. Ensure **joint ownership of intellectual property (IP)** when implementing American processing technologies—so that Uzbekistan receives not only rent but also the rights to the technologies.

Benefits for all parties:

- **For Uzbekistan** — a transition from simple extraction and export of raw materials to the production of high-value-added products, development of processing capacities, creation of new jobs, and strengthening of the country's export potential.
- **For the US** — the opportunity to diversify sources of critical mineral supplies outside of China, ensure the stability of its "green" industries, and establish long-term partnerships in a strategically important region.
- **For the region as a whole** — the formation of a new resource-industrial base and the creation of integrated value chains in Eurasia, which will contribute to economic growth, technological development, and the strengthening of regional resilience.

Justification:

- **Technical:** Uzbekistan does not possess modern aeromagnetic survey, remote sensing, and geochemical sampling technologies, whereas US experience and equipment will ensure the accuracy and international recognition of the data.
- **Financial:** The participation of American institutions (USGS, DFC) will provide co-financing and reduce risks for the budget, while the results will increase the investment attractiveness of the mining sector.
- **Geopolitical:** Critical minerals are a strategic resource for the US and its allies; participation in their exploration in Central Asia will allow Washington to strengthen its position in forming alternative supply chains, reducing dependence on China.

3. Inviting American companies for exploration and extraction of uranium deposits.

Uzbekistan and Kazakhstan are the two largest uranium suppliers in Eurasia. In the context of the energy transition and the growing role of nuclear power, the US is looking for reliable fuel supply partners, especially amid the reduction of its own reserves. However, cooperation must go beyond extraction—it is necessary to develop local capacities for conversion, enrichment, and the production of fuel components.

Proposals:

1. Create a **US–Uzbek Nuclear Technology Cooperation Program** for joint uranium processing and personnel training.
2. Organize a **Competence Center for Nuclear Safety and Enrichment Technologies** in Uzbekistan, certified by the IAEA.

Goal of cooperation: Development of cooperation in the sphere of exploration, extraction, and processing of uranium to form sustainable and safe nuclear fuel supply chains on a global scale.

Mutually beneficial prospects for cooperation participants:

- **For Uzbekistan** — this is not just uranium export, but full participation in the nuclear fuel and related technology value chain, which will increase the level of technological independence and create a basis for national competence in nuclear energy.
- **For the US** — strengthening its own fuel supply chains and reducing dependence on nuclear raw material imports from Russia and China, as well as forming a reliable strategic partnership in Central Asia.
- **For the region as a whole** — the development of safe and transparent nuclear infrastructure certified by international institutions, which will ensure a high level of environmental and technological responsibility and strengthen the region's reputation as a reliable partner in global nuclear energy.

Justification:

- **Technical:** American companies have experience in environmentally safe extraction (in-situ leaching, radiation control, closed-loop processing cycles), which complies with international IAEA standards.
- **Financial:** Attracting private capital and credit lines from the US will reduce risks, allowing for the accelerated modernization of existing enterprises and the development of new deposits.
- **Geopolitical:** The US has its own uranium reserves of less than 0.1%, while Uzbekistan owns about 7% of world reserves. In the context of global uranium market redistribution (Kazakhstan - 44%, Russia - 5%, China - 3%), US participation in Uzbekistan's projects will become a geostatistical element of Western energy security and strengthen bilateral ties within the C5+1.

The expansion of the C5+1 platform to include the countries of the South Caucasus (Azerbaijan and Georgia) and Afghanistan forms a new strategic logic for regional interaction. These states are becoming key bridges for energy and logistics corridors connecting Central Asia with Europe, the Middle East, and South Asia. The Trans-Caspian energy route will ensure the export of gas, electricity, and hydrogen in a westward direction, while the Trans-Caspian International Transport Route (TITR) creates a direct exit for Central Asia to the Black Sea and European markets.

Simultaneously, the Afghan southern corridor opens alternative routes to the ports of India and Pakistan, increasing the flexibility and stability of critical mineral and energy resource supplies.

For the effective implementation of these areas, it is proposed to create the **C5+1+ Trans-Caspian Energy & Logistics Initiative**, aimed at the comprehensive integration of the region's transport, energy, and digital infrastructure. Within the framework of this initiative, it is advisable to develop a unified system of energy certificates (**Green Certificates**) for exported electricity from renewable sources, allowing countries of the region to enter international "green" markets. Furthermore, with the support of the US, Uzbekistan, Azerbaijan, and Kazakhstan, regional renewable energy and hydrogen hubs should be developed, which will become centers for the generation, accumulation, and export of clean energy, contributing to the formation of a sustainable and interconnected energy architecture in Eurasia.

Analysis of the prospects for energy cooperation between Russia and the USA today is not a question of economic expediency, but a question of global political geometry.

I. Oil Sector

Until 2022, the USA imported about 670,000 barrels of oil and petroleum products per day from the RF, predominantly heavy fractions for refineries. After the introduction of the embargo in March 2022 and the departure of ExxonMobil, BP, and Shell from Russian projects, cooperation ceased. ExxonMobil left the "Sakhalin-1" project, and BP lost a stake in Rosneft's capital valued at $25 billion. By 2023, oil production in the USA reached 12.9 million barrels per day—a historical maximum (EIA data). The RF maintains production at the level of 10–11 million barrels, preserving participation in the OPEC+ format and reorienting exports to Asia. The USA is not part of OPEC but exerts significant influence on prices using strategic reserves and coalition tools like the G7 price cap ($60/barrel). In the medium term (until 2030), a competitive model is expected to persist: the RF strengthens export ties with Asia and the countries of the Global South (India, China, Indonesia, Vietnam, Pakistan, Africa, Latin America, and the Middle East), while the USA reinforces its position as a global supplier of oil and LNG for Europe and its allies.

II. Gas Sector

Until 2022, the RF provided about 40% of EU gas imports (around 150 billion m^3 per year). After the termination of contracts and the sabotage of the "Nord Stream" infrastructure, its share decreased to 10–11%, or about 45–50 billion m^3 (2024). Simultaneously, the USA became the largest exporter of liquefied natural gas (LNG). In 2023, the volume of American LNG exports reached about 215 billion m^3 per year, of which up to 70% was directed to Europe. American supplies became key for the implementation of the REPowerEU program, adopted by the European Commission in 2022 and aimed at a complete phase-out of Russian energy resources by 2027. Thus, the USA not only strengthened its economic presence in Europe but also increased its political influence, turning energy into an instrument of strategic partnership with the EU.

Indirect influence of Russia through transit routes.

Despite the official reduction of direct supplies, part of Russian gas continues to reach Europe through intermediaries and blended flows. Turkey plays a central role in this, having become a key transit hub. Through the TurkStream pipeline (capacity — 31.5 billion m^3 per year), the RF supplies gas both for Turkish needs and in transit to Bulgaria, Hungary, Serbia, and Greece. Turkey is actively promoting the idea of creating a gas hub where flows from the RF, Azerbaijan, and Iran will be merged. This allows for the formation of an "energy mix" without a precise indication of the fuel's origin. According to Reuters and CSD Europe (2024), supplies through the Strandja–Malkochlar point (Turkey–Bulgaria border) grew after 2022, and part of these volumes could include Russian gas. The European Commission officially stated the need for transparency on these routes. De facto, the RF has maintained an indirect presence on the European market, and Turkey has strengthened its status as a regional energy hub. For Europe, this remains a pragmatic compromise between the need for diversification and energy security.

III. Nuclear Energy

Nuclear energy remains the only sphere where interaction between the RF and the USA has not been completely interrupted. As of 2023, about 25% of the enriched uranium used in American NPPs was supplied from the RF. In 2024, the US Congress passed law H.R.1042, providing for a gradual phase-out of Russian fuel imports until 2028, but exceptions remain during the transition period due to the dependence of American reactors on Russian isotopes. Both countries are investing in new technologies: the USA is promoting small modular reactors (SMRs) and its own uranium enrichment, while the RF is expanding Rosatom's international projects (in Turkey, Egypt, India, and Bangladesh). This reflects the formation of two technological centers of influence in the global nuclear market.

A special place is occupied by the **ITER** (International Thermonuclear Experimental Reactor) project—the world's largest international experiment to create a thermonuclear reactor in France. ITER unites 35 countries, including the RF and the USA, and is aimed at obtaining energy by fusing hydrogen atoms—just as it happens on the Sun. Despite political disagreements, the RF continues to fulfill its obligations, supplying equipment and materials. Participation in ITER remains a rare example of scientific cooperation persisting even under conditions of global tension.

IV. Global Consequences and Prospects

Formation of a new energy architecture.

The confrontation and restriction of direct energy ties between the RF and the USA have led to a deep restructuring of the global energy architecture. Instead of the former bipolar system (supplier–consumer), a multipolar network of interdependent routes is forming, where key positions have been taken by transit and intermediary states—Turkey, Qatar, India, and China. After 2022, Russia has been actively diversifying its exports, reorienting oil and gas from Europe to the East and South. While until 2022 about 55% of hydrocarbon exports went to the EU, by 2025 over 75% of oil and gas is supplied to the countries of Asia, the Middle East, and the Global South. This pivot is driven not only by sanctions but also by the desire to establish a foothold in new fast-growing regions where energy demand persists and contract terms are more flexible.

Turkey as an energy intermediary.

Turkey has become a central element of the new energy logistics. Through the TurkStream pipeline (31.5 billion m^3 per year), Russian gas is supplied not only to the domestic market but also to Bulgaria, Hungary, Serbia, and Greece. Turkey promotes the concept of a Turkish gas hub where flows from the RF, Azerbaijan, and Iran will be mixed. Such a scheme allows for the formation of an "energy mix" without specifying the fuel's origin. This is beneficial for all participants at once:

- **RF** — export revenue and political influence are preserved;
- **Turkey** — the role of a regional energy center is strengthened;
- **Europe** — partial energy flexibility is ensured without direct violation of sanctions.

Facts confirming this model are cited by Reuters and CSD Europe (2024): supplies through the Strandja–Malkochlar border point grew by a third, and the origin of part of the gas remains unclear. The European Commission recognized the need for transparency in such schemes, but at the same time, they continue to function as a compromise between politics and energy needs.

India, the Middle East, and Global South countries.

In addition to Turkey, India, China, and the Middle East have become key directions.

- **India** has turned into one of the largest buyers of Russian oil. Its imports grew from less than 2% in 2021 to more than 30% of total oil imports in 2024. Indian refineries process Russian oil, after which the products are supplied to the world market, including Europe. This creates an indirect channel for the presence of Russian oil in Western markets.
- **China** has become the main strategic direction for Russian gas. The volume of supplies via "Power of Siberia" in 2024 amounted to 22 billion m^3, and by 2027 it should reach the

design capacity of 38 billion m^3. Negotiations are underway for the construction of "Power of Siberia-2," which will allow for nearly doubling exports.

- **The Middle East** is becoming a new market and partner. The RF is negotiating LNG supplies to Bahrain and cooperating with the UAE on energy infrastructure issues. According to Reuters (May 2025), negotiations on long-term contracts are in an advanced stage.

These ties create a South-Eastern energy belt, where the RF establishes itself as a supplier, and the countries of the region receive reliable sources of resources and political dividends.

Global effects and influence on the USA.

For the USA, the energy configuration that emerged after 2022 carries a dual effect. On the one hand, the USA strengthened its economic presence in Europe, becoming the main supplier of LNG (up to 50% of EU imports). On the other hand, the expansion of the RF's energy presence in Asia and the Middle East means that US influence in these regions is limited.

Thus, the global energy system is shifting from a hierarchical model to a network model, where there is no longer a single center. This structure makes markets simultaneously more flexible and more vulnerable:

- Any disruptions at transit hubs (Bosporus, Suez, Hormuz) can cause sharp price fluctuations.
- The role of political stability in intermediaries—Turkey, Egypt, Qatar—increases.
- Competition intensifies not only for sales markets but also for technologies, investments, and decarbonization standards.

Energy interaction between the RF and the USA, having passed through a stage of sanctions and confrontation, remains a system-forming factor in global energy. Even with minimal direct contacts, both countries continue to determine the balance of power, form price benchmarks, and technological standards. The prospects for direct cooperation in the coming years remain limited.

Cybersecurity in the Energy Sector: Significance for Uzbekistan in Central Asia

The energy sector of Uzbekistan is the foundation of the national economy and a key element of regional interdependence. In the era of digitalization, energy assets are becoming targets not only of physical threats but also of cyber threats. For Uzbekistan, located at the center of the Unified Energy System of Central Asia (UESCA), cybersecurity is not merely a technical issue but a strategic factor for national and regional stability.

Uzbekistan's energy sector produces and distributes more than 60 billion kWh per year, providing over 80% of the region's industrial consumption. In recent years, digital technologies have been actively implemented in the energy sector:

- Automated process control systems (SCADA, DCS);
- Smart meters and digital substations;
- Cloud platforms for demand forecasting and generation optimization.

This digitalization increases efficiency but also opens new vulnerabilities—from attacks on network equipment to the manipulation of dispatching data.

The UESCA connects the energy grids of Kazakhstan, Uzbekistan, Kyrgyzstan, Tajikistan, and partially Turkmenistan. Any failure in one country is capable of causing cascading effects. An example was the blackout of January 2022, which began in Uzbekistan and led to power outages in three countries. Under these conditions, a cyberattack on the Uzbek energy system could have transboundary consequences—not only economic but also political. Therefore, ensuring the digital resilience of Uzbekistan's energy sector effectively means strengthening the entire UESCA.

The state of cybersecurity in Uzbekistan's energy sector logically follows from the characteristics of the regional energy system. Therefore, the assessment of the current state of protection within the country must be considered in conjunction with the UESCA context. The regulatory and legal framework in the field of energy cybersecurity has already been formed, but it is declarative in nature and is not integrated into industry processes. The main documents are as follows:

№	Regulatory Document	Content and Purpose	Key Limitations
1	Law of the Republic of Uzbekistan "On Cybersecurity" (2022)	- Defines general principles for the protection of critical information infrastructure (CII). - Forms the basic system of state control over the security of digital systems.	- Does not contain industry-specific technical regulations. - Lacks enforcement mechanisms. - Views cybersecurity as an element of national security rather than engineering reliability.
2	State Program "Digital Uzbekistan – 2030"	- Strategic program for the digitalization of the economy and infrastructure, including energy.	- Does not establish mandatory cyber protection criteria for SCADA, ICS, and substations. - Digitalization outpaces the development of protection systems.
3	Resolutions of the Cabinet of Ministers and departmental orders on CII	- Regulate the registration, classification, and audit of critical infrastructure objects. - Define the powers of the State Security Service (SGB) as the main supervisory body.	- No technical standards at the level of ISA/IEC 62443 or ISO/IEC 27019. - Lack of integration with international practices. - Control prevails over engineering risk management.
4	Bylaws on the certification of equipment and software	- Establish requirements for the certification of IT systems in government	- Do not extend to industrial networks (OT).

		agencies, banks, and other sectors.	- No unified mechanism for assessing vulnerabilities of energy equipment before commissioning. - No system of mandatory security tests for imported solutions.

Thus, the regulatory architecture exists but bears a control-declarative character, failing to create a link between policy, technology, and operational management. At the same time, the centralization of functions in the field of cybersecurity is anchored by the Law of the Republic of Uzbekistan "On Cybersecurity" (2022) and Cabinet of Ministers Resolution No. 332 dated July 11, 2022, according to which the State Security Service (SGB) is designated as the main body for the control and supervision of critical information infrastructure protection. The Ministry of Energy, JSC "National Electric Grid of Uzbekistan," and Regional Electric Grids act only as executors of established requirements, lacking the right to develop their own technical regulations or standards. The absence of industry standards (e.g., ISA/IEC 62443, ISO 27019) and internal regulatory mechanisms leads to energy security being assessed by formal compliance rather than the actual resilience of the grids—forming a typical "compliance trap."

The technical state reflects the same contradictions. Uzbekistan's energy system is actively digitalizing: SCADA systems, smart substations, and remote control centers are being implemented. However, most solutions are based on imported platforms of Russian, Chinese, Turkish, and European origin. Main vulnerabilities include:

- Lack of network segmentation between IT and OT;
- Use of controllers without built-in protection;
- Absence of a unified center for monitoring cyber incidents;
- Underdevelopment of intrusion detection systems and event analysis.

According to OECD data, over 70% of companies in Uzbekistan experience a shortage of qualified specialists in digital technologies and cybersecurity. In the energy sector, this is more acute: there is a lack of personnel combining IT and OT competencies, and educational programs do not cover ISA/IEC 62443 standards and SCADA/ICS protection. As noted by ResearchGate, the country maintains "structural gaps in training and the practice of industry exercises," making the human resource base inconsistent with the level of cyber threats.

The information secrecy surrounding cyber incidents in the energy sector is confirmed by the absence of public reports and transparent investigation mechanisms. According to a World Bank analysis (2024) and the ADB review "Energy Sector Cybersecurity Frameworks in Asia" (2023), in Central Asian countries, including Uzbekistan, incident investigations "are conducted in a closed manner without the publication of technical findings or data exchange between operators." This contrasts sharply with the practice of ENTSO-E (EU), where unified reports are published for all grid participants after every failure. The absence of a unified registry of vulnerabilities and a breach notification system prevents the formation of collective response experience. As a result, even major failures in 2023–2024 did not become the subject of inter-agency analysis, hindering the prevention of recurring errors.

Ultimately, the cybersecurity system of Uzbekistan's energy sector today represents a formally structured but functionally unstable circuit. Laws exist but are not embedded in practice; control exists but without engineering depth; digitalization is progressing but without protection. Outwardly, order is maintained, but internal resilience is minimal. This state is not just an internal risk—it is a factor of regional vulnerability: the weakness of one node in the UESCA is capable of causing systemic consequences for all countries in the region. Strengthening the regulatory and technical base of energy cybersecurity in Uzbekistan is, in essence, strengthening the entire architecture of energy stability in Central Asia.

To increase energy cyber resilience, Uzbekistan can rely on international practices:

- **ISA/IEC 62443:** Protection of Industrial Automation and Control Systems (IACS), network segmentation.
- **ISO/IEC 27019:** Risk management in the energy sector.
- **NERC CIP (USA):** Mandatory standards for grid operators.
- **EU NCCS:** Transboundary cyber risk management in EU energy systems.

Integrating these standards into national regulations will create the basis for a transition from a reactive to a proactive protection model. In this regard, the creation of an **Inter-agency Center for Cybersecurity in Energy (ICCE)** will allow for the pooling of efforts from the SGB, Ministry of Energy, "National Electric Grid of Uzbekistan," and "Regional Electric Grids" for practical coordination and the implementation of international standards ISA/IEC 62443 and ISO 27019 in all industry projects. Priority steps include the creation of:

1. **Sectoral Security Operations Center (SOC):** A unified platform for real-time analysis of events in operational networks (OT), with the capability for rapid incident response.

2. **National Defense and Recovery Plans (UFLS, Black Start):** Development and regular testing of algorithms for emergency shutdown and recovery of the energy system after attacks or failures.

3. **Regional Information Sharing and Analysis Center (ISAC/CA):** A mechanism for joint response and threat data exchange between Uzbekistan, Kazakhstan, Kyrgyzstan, and Tajikistan to prevent cascading risks in the Unified Energy System of Central Asia.

4. **Educational programs** within the higher education system in specialized universities focusing on cybersecurity for the energy sector.

Strengthening the cybersecurity of the energy sector reinforces not only internal resilience but also Uzbekistan's international standing. A reliable digital infrastructure increases energy autonomy, reduces dependence on external risks, and builds the country's reputation as a responsible and technologically mature partner in regional projects. For Central Asia, this means a reduction in the probability of cascading failures, increased trust between operators, and the creation of a base for regional cyber coordination.

The events of the first week of January 2026, which concluded with a forceful change of power in Caracas and the establishment of a temporary administration under US patronage, have become a "Black Swan" whose scale exceeds the consequences of the Arab Spring or the 1973 oil crisis. Venezuela is not just another petro-state; it is the holder of 303 billion barrels of proven oil reserves (according to the BP Statistical Review of World Energy), which accounts for about 17-18% of all global reserves, exceeding the figures of Saudi Arabia (267 billion). The transition of this giant resource reservoir from the sphere of influence of the Sino-Russian block to the control of Western majors (IOCs - International Oil Companies) fundamentally changes the balance of power. We are witnessing the end of the era of a "bipolar oil world," where OPEC+ could dictate terms, and the beginning of the formation of a "Pan-American Energy Alliance" (USA - Canada - Brazil - Venezuela), capable of ensuring complete energy autonomy for the West.

Despite strategic expectations of falling prices in the future, the current market reaction (January 2026) is characterized by panic growth and high volatility. This is due to three critical factors:

1. **Infrastructure Collapse and the "Iraq Effect."** The market fears a repetition of the 2003 Iraq scenario. After the overthrow of Saddam Hussein, production did not recover for years due to sabotage. The condition of the Venezuelan state company PDVSA as of January 2026 is catastrophic. Of 30,000 wells, fewer than 3,000 are in working order. Key infrastructure in the Orinoco belt, including heavy oil upgrader complexes "Petromonagas" and "Petropiar," is 70-80% worn out. Current production, which fluctuated in 2024–2025 at the level of 850,000 barrels per day (bpd), is currently under threat of a total zeroing out. A series of strikes by unions loyal to the "Chavistas" and guerrilla attacks on pipelines connecting fields to export terminals in Jose are expected. Goldman Sachs analysts predict a loss of up to 600,000 bpd in the next two months, which will create a local deficit.

2. **Heavy Oil Crisis (Heavy Sour Crunch).** The global oil market is not homogeneous. A global deficit is observed precisely in the segment of heavy sour crude (API < 22, sulfur content > 2%), the benchmark for which is the Venezuelan grade Merey-16. US refineries on the Gulf Coast

(PADD 3) are technologically designed to process precisely such oil to obtain diesel fuel and fuel oil. Replacing Venezuelan oil with light shale oil (WTI) is impossible without a loss of refining efficiency. Any supply interruption now drives up prices for heavy grades (Maya, Western Canadian Select) and, consequently, for diesel fuel worldwide.

3. **Speculative Premium.** A "war premium" of $7-12 is currently being priced into the Brent barrel. Traders are hedging risks that the conflict might spread to neighboring Guyana (where ExxonMobil produces more than 1.2 million bpd), given the Maduro regime's recent territorial claims to the Essequibo region. Until the situation stabilizes, volatility will exceed 40-50% in annual terms.

The Chinese Gambit: Loss of Strategic Rear

For China, the fall of the Maduro regime is perhaps the most painful geopolitical defeat of the decade, having a specific monetary expression. Beijing invested, by various estimates, from $62 to $65 billion in Venezuela under the "loans for oil" program. The new administration in Caracas, supported by the IMF and the US Treasury, is highly likely to announce an audit of external debt. There is a real risk of recognizing part of the Chinese loans as "odious debt"—a legal term allowing for the non-repayment of debts taken by dictatorial regimes not in the interests of the people. Even in a mild scenario, China faces a deep restructuring (haircut) with a loss of 50-70% of the nominal value.

Independent refineries in Shandong province (the so-called "teapots"), which provide about 20% of refining in China, built their business model on processing sanctioned oil. They bought Venezuelan oil labeled as "Malaysian blend" or bitumen at a discount of $20-30 to Brent. The normalization of relations between Venezuela and the US removes this discount. Oil will go at market prices to Houston, not Qingdao. For Chinese refineries, this means a drop in refining margins to negative values and a wave of bankruptcies. The huge "Dark Fleet"—hundreds of old tankers with disabled transponders carrying oil to China—instantly loses its freight. This will lead to a collapse of rates in the gray shipping market but will cause a sharp increase in demand for legal VLCC class tankers for supplies to the US, which will inflate the cost of official logistics.

The Russian Federation: Threat to Market Share

The impact on Russia is not so much political (loss of an ally) as it is economic. Russia owns stakes in five joint ventures with PDVSA (including Petromonagas and Boqueron). Historical parallel: in 2007, Hugo Chavez nationalized the assets of ExxonMobil and ConocoPhillips. In 2026, the

pendulum has swung back. The new government is likely to initiate a review of contracts concluded under Maduro under the pretext of corruption. Russian assets may be frozen or transferred to American corporations as compensation for past expropriations.

Since 2022, Russia has reoriented Urals oil exports to India (up to 40% of the country's imports). Russian Urals and Venezuelan Merey-16 are medium and high-density grades. Indian refineries (Reliance in Jamnagar, Nayara Energy) are technically "omnivorous" and are among the most complex in the world. As soon as sanctions are lifted from Venezuela (expected within 3-6 months), Venezuelan oil will become a legal alternative for India. This will give New Delhi powerful leverage over Moscow. This will lead to an expansion of the Urals discount to Brent, reducing Russian budget revenues.

OPEC+ and the Middle East

Venezuela, possessing the potential to increase production from the current 0.8 to 2.5-3.0 million bpd in 3-4 years (with investments of $15-20 billion per year), will not comply with OPEC quotas. The country needs money for recovery and will pump at maximum capacity. For Saudi Arabia, this means the appearance on the market of a volume equivalent to the entire export of Kuwait, which Riyadh cannot control. To compensate for this influx, OPEC+ will have to cut quotas even deeper, which is already technically difficult (Saudi Arabia is already producing below 9 million bpd). A repeat of the 2014 scenario is likely: Saudi Arabia may decide not to cede market share and "open the taps," crashing the price to $40 per barrel to stifle investment in the Venezuelan sector at an early stage. But in 2026, the Saudis have fewer financial reserves for such a war than they had 12 years ago.

Long-term Outlook (2027–2030)

On the horizon of 2027–2030, the global energy landscape is likely to change radically. Venezuelan fields in the Orinoco belt are geologically uncomplicated but require technologies (SAGD - steam-assisted gravity drainage, diluents) possessed by Chevron and Schlumberger. The return of these companies will allow for a reduction in the cost of production in Venezuela to $10-12 per barrel, comparable to the Middle East. At the same time, the US gains access to a full cycle:

- **USA:** Light shale oil.
- **Canada and Venezuela:** Heavy oil and bituminous sands.
- **Gulf of Mexico:** The world's largest refining hub.

This closed circuit makes the Western Hemisphere absolutely independent of supplies from the Middle East. This reduces the geopolitical significance of the Strait of Hormuz and the Suez Canal. In the long term (after passing the chaos phase of 2026), the world is likely to face a period of low oil prices ($55-65 per barrel in 2026 prices). Excess supply from a revitalized Venezuela, coupled with slowing demand in China and the energy transition, will create a structural surplus.

The events of recent months in Venezuela and Iran have transcended local political crises. When viewed in a unified context, a clear strategy emerges: the creation of zones of instability around key energy suppliers to China. The US, possessing energy independence (due to the shale revolution and mothballed oil and gas fields), has shifted to a tactic of "cutting off" competitors from cheap raw materials. The goal is obvious: to artificially inflate energy prices for Chinese industry or to cut them off from major stable suppliers entirely, which will inevitably lead to a decrease in the GDP growth rates and technological development of the PRC.

Venezuela: Loss of the Caribbean Oil Hub

The change in the political vector in Venezuela strikes at one of Beijing's oldest "insurance" assets. According to available data, the last shipments of heavy oil are departing from the ports of Jose and Puerto la Cruz toward Chinese refineries under old intergovernmental agreements (loans for oil). Chinese refineries (especially the independent "teapots" in Shandong province) are technologically tailored for Venezuelan heavy oil (Merey 16). Replacing this grade with lighter Middle Eastern or expensive Canadian oil requires equipment reconfiguration (time) and reduces refining margins (money). Beijing has invested over $60 billion in Venezuela over the last 15 years. A regime change calls into question the return of these investments and, more importantly, terminates access to the largest proven oil reserves in the world, which China viewed as a strategic reserve in the event of military conflicts.

Iran: Burning Hormuz and the End of "Shadow Imports"

The conflict in Iran, which is highly likely on pause right now, will be protracted and will strike at the most sensitive part of Chinese imports. Iran supplied China with up to 1.5 million barrels per day at discounted prices, bypassing sanctions (often via the shadow fleet of Malaysia). Regional destabilization physically limits shipping capabilities. Any escalation in this "bottleneck" (the Strait of Hormuz, through which 20% of the world's oil passes) hits Asian consumers specifically. The US, consuming its own and Canadian/Mexican oil, is practically independent of the strait, while for China, the closure of Hormuz represents an energy collapse. To be fair, US partners—Qatar and

Saudi Arabia—will also suffer. For this reason, these countries were apparently against the escalation of the conflict.

US Strategy: Containment through "Energy Hunger"

The US is implementing a strategy of indirect action. Direct military confrontation with China is fraught with nuclear conflict; therefore, the path of strangling the economy through resource deficits has been chosen. China's economy is energy-deficient (importing >70% of oil, >40% of gas). To produce goods and, crucially, to maintain energy-intensive data centers for AI development, China needs cheap energy. The methodology used by the US may not be obvious, but it has its own logic and effect. The US is trying to "knock out" China's main suppliers: Russia (sanctions, price caps, and technological limitations), Iran (threat of war and sanctions), and Venezuela (regime change). The US aims to force China to buy oil through intermediaries, with high insurance premiums and logistical costs. This will make Chinese goods more expensive, reducing their competitiveness compared to goods from the US or allied countries (India, Vietnam).

Infrastructure Under the Crosshairs: Maritime Arteries and Pipelines

Primarily, the US maintains dominance in the World Ocean, which threatens maritime supplies to the PRC.

- **Malacca Strait:** The main route for oil from the Middle East and Africa. The US Navy can block it within 24 hours.
- **South China Sea:** Escalating tensions around Taiwan and the Philippines create risks for the PRC's tanker fleet as it approaches ports.

Regarding gas pipelines, oil pipelines, and land-based risks: given the risks at sea, China has bet on pipelines. However, they are also becoming targets for hybrid attacks (sabotage, cyberattacks, local conflicts along the route).

- **"Power of Siberia" (RF - PRC):** Relatively safe but depends on Moscow's political will.
- **Myanmar - China:** A pipeline allowing the bypass of the Malacca Strait. A civil war continues in Myanmar, which periodically threatens the operation of the pipe.

Central Asia: The Next Front of Hybrid War?

This is the most critical aspect for regional security. Central Asia (Turkmenistan, Uzbekistan, Kazakhstan) is a key supplier of pipeline gas to China (the Central Asia - China gas pipeline, lines A, B, C, and the construction of branch D). Gas from Central Asia travels by land, meaning it is beyond

the reach of the US Navy. This makes the supplies too reliable and safe for Beijing, which likely contradicts Washington's containment strategy. To cut this artery, missiles are not needed. Political destabilization in transit countries is sufficient.

We are witnessing the implementation of a global strategy to "encircle" China with zones of managed chaos. Following Venezuela and Iran, the focus of tension will inevitably shift to Central Asia and Africa (where China mines rare metals). For the countries of Central Asia, this means entering a zone of increased turbulence. Their role as a reliable rear for the PRC economy makes them a priority target for those forces interested in slowing down Chinese growth. The issues of protecting critical infrastructure (gas pipelines) and internal political stability are becoming matters of survival for sovereignty.

Introduction

Energy security is usually defined as ensuring reliable and uninterrupted access to energy resources at an affordable price. This is a complex concept that includes technical, economic, geopolitical, and environmental aspects. Amidst growing global energy demand and the global transition to a low-carbon economy, countries face a dual task—guaranteeing the stability of energy supply and simultaneously ensuring resilience to climate change. Key areas for strengthening energy security include diversifying energy sources, implementing new technologies, developing renewable energy sources (RES) and nuclear power, improving energy efficiency, formulating sound state policies, and accounting for geopolitical risks.

This article examines the experience of the world's leading economies—Germany, Japan, the USA, China—as well as countries comparable to Uzbekistan in terms of energy development—Kazakhstan, Egypt, and Iran. Special attention is paid to a comparative analysis with Uzbekistan's situation: the structure of the energy balance, the degree of import dependence, the share of RES, and the presence of nuclear generation. Based on successful international practices, recommendations have been formulated to strengthen the energy security of the Republic of Uzbekistan.

Methodology

The methodology of this study is cross-country comparative. For examples, large developed economies (Germany, Japan, USA, China) demonstrating various approaches to ensuring energy security in the context of the energy transition were chosen on one hand, and countries close to Uzbekistan in terms of the level and structure of the energy system (Kazakhstan, Egypt, Iran) on the other. This choice allows for comparing the strategies of leading countries with conditions more similar to those in Uzbekistan and identifying common patterns and specific solutions.

The analysis relies on a review of statistical data and policy documents. Reports from the International Energy Agency (IEA), the World Bank, and other organizations were used, as well as national strategies and industry reviews for each of the countries considered. For a unified comparison of key indicators, a summary table has been compiled, reflecting the shares of various

energy sources in electricity generation and the level of import dependence as of 2021–2022. The indicators are calculated based on current data from international and national sources. The main emphasis is on a qualitative analysis of strategies and policy measures; however, quantitative indicators (RES shares, import/export volumes, emission reduction targets, etc.) are used for an objective assessment of progress. The final recommendations are synthesized based on the identified best practices, taking into account the specifics of Uzbekistan.

Strategies of leading countries

Germany: Energy Transition and Supply Stability

Germany is known for its national Energiewende (energy transition) strategy—a systematic transition to renewable and low-carbon energy. The country has set ambitious goals: to reach carbon neutrality by 2045 and increase the share of renewable sources to 80% in electricity generation by 2030. To achieve this, an extensive package of measures has been adopted—from legislative reforms simplifying the deployment of wind and solar power plants to stimulating hydrogen technologies and increasing energy efficiency. Specifically, it is planned to install 100–110 GW of onshore wind capacity, 30 GW of offshore wind farms, and up to 200 GW of solar power plants by 2030. Simultaneously, Germany intends to reduce final energy consumption by ~20% by 2030 through increased efficiency.

Historically, Germany's energy balance largely relied on imported hydrocarbons—oil and natural gas. On the eve of the 2022 energy crisis, about 70% of primary energy resources were imported, primarily oil and gas. This dependence on one large supplier—Russian gas—became a vulnerability: after geopolitical escalation in 2022, gas supplies from the RF ceased, which dealt a serious blow to the country's energy security. Germany responded promptly by diversifying gas supplies (through the accelerated launch of LNG import terminals and increased gas purchases from Norway) and strengthening energy conservation and RES support programs. Learning from the crisis, the government emphasized that an accelerated transition to clean energy is the best long-term way to reduce import dependence and ensure price stability.

From a technology and policy perspective, Germany was one of the pioneers in supporting renewable energy (since the 2000s via Feed-in Tariffs and later through an auction system) and implementing energy storage. In recent years, significant investments have been directed towards modernizing power grids and creating backup capacities—predominantly gas-fired (hydrogen in the future)—to balance variable generation. Geopolitically, Germany is now building more balanced

relations with different energy suppliers, developing its own LNG terminal infrastructure, and increasing strategic fuel reserves. Nuclear power, conversely, is being phased out in Germany—the last active NPPs were permanently shut down in April 2023. This political decision was dictated by safety considerations and public consensus, although some experts note that abandoning nuclear power complicated the task of decarbonization and short-term stability.

Japan: Balance of Imports, Nuclear, and RES

Japan faces unique energy security challenges: being poor in its own fossil resources, the country is forced to import about 90% of all energy resources. After the 1973 oil crisis, Japan bet on the development of nuclear power as a strategic priority to reduce dependence on oil imports. By 2010, approximately 30% of electricity was generated at NPPs. However, the Fukushima-1 accident in 2011 led to the shutdown of all nuclear reactors and a sharp increase in LNG and oil imports to compensate for the lost generation.

In recent years, Japan has been gradually restarting some previously stopped reactors. As of early 2024, 14 reactors have resumed operation. The government set a new goal—to increase the share of nuclear generation to ~20% by 2030. Simultaneously, there is active development of renewable sources: programs supporting solar energy (Japan is one of the world leaders in installed solar capacity) and offshore wind power are in place. Japan's energy security policy is based on the "3E+S" concept (Energy Security, Economic Efficiency, Environment + Safety). Geopolitically, Tokyo seeks to secure fuel supply routes and enters into long-term contracts. Japanese companies hold stakes in major LNG projects abroad and even maintained participation in the Russian "Sakhalin-2" project after 2022 to prevent an LNG shortage.

USA: From Energy Deficit to Export and Technological Leadership

The United States of America over the last 15 years has made a leap from an import-dependent model to the status of one of the world's largest energy exporters. The so-called "shale revolution" cardinally changed the situation: the USA became a world leader in oil and natural gas production and turned from a major importer into a net exporter. Since 2019, the country has, for the first time in almost 70 years, exported more total energy resources than it imports.

Today, the US energy balance is characterized by a high share of domestic resources. In the electricity sector, about 60% of generation is provided by fossil sources (predominantly cheap natural gas and still significant coal), ~20% by nuclear power (the USA possesses the world's largest

nuclear generation), and ~20% by renewable sources. Technological leadership is the key trump card of the USA. American companies and research centers hold leading positions in energy innovations: from horizontal drilling technologies to developments in "smart" grids, energy storage, small modular reactors (SMRs), and hydrogen energy. In 2022, the massive Inflation Reduction Act (IRA) was passed, providing for unprecedented investments in clean energy and localized equipment production.

China: Maximizing Domestic Resources and Global Expansion

China faces a complex dual task—satisfying the rapidly growing demand of the world's largest economy and meeting environmental commitments. On one hand, China still relies on coal as the main source: about 60% of electricity generation comes from fossil fuels, with coal making up the lion's share. In 2022 alone, China approved the construction of nearly 90 GW of new coal-fired TPPs.

At the same time, China leads in the development of RES and nuclear power. The country has installed over 300 GW of wind generators and about 400 GW of solar panels (No. 1 in the world for both). By 2030, China aims to reach 1200 GW of combined wind and solar capacity. Nuclear generation is growing rapidly: over 50 power units are in operation, with dozens more under construction. Geopolitically, although China is nearly autonomous in electricity, it has become the world's largest importer of oil and gas. To counter the vulnerability of sea routes (e.g., the Malacca Strait), Beijing has invested in alternative delivery routes: pipelines from Central Asia and Eastern Siberia, and a pipeline from Myanmar. China dominates the production of solar panels (about 70% of global output) and lithium-ion batteries. The Chinese experience is a bet on scale and diversification under strict state planning.

Comparison with peer countries

To assess Uzbekistan's position, it is advisable to compare the key indicators of energy sectors with countries having a similar level or structure of energy.

Country	Fossil Fuel in Electricity	RES (incl. Hydro) in Electricity	Nuclear Energy in Electricity	Import Dependence
Germany	~50% (coal, gas, oil)	~45% (wind, solar, bio, hydro)	~0% (as of 2023)	High (imports ~70%)

Japan	~69% (gas, coal, oil)	~22% (hydro, solar, wind, bio)	~7% (target ~20% by 2030)	Very High (imports ~90%)
USA	~60% (gas, coal, oil)	~20% (wind, hydro, solar, etc.)	~20%	Low (Net exporter since 2019)
China	~65% (coal, gas, oil)	~30% (hydro, wind, solar, bio)	~5%	High (oil, gas imports)
Kazakhstan	~90% (coal, gas, oil)	~10% (hydro, wind, solar)	0%	Low (Large exporter)
Egypt	~85% (gas, oil)	~15% (hydro, wind, solar)	0% (NPP under construction)	Low (Close to balance)
Iran	~94% (natural gas, oil)	~2% (hydro; RES emerging)	~4%	Low (Nearly autonomous)
Uzbekistan	~88% (natural gas, coal)	~12% (hydro; solar/wind emerging)	0% (NPP planned)	Low (Current balance, import risk)

Note: Data rounded; values based on 2021–2022 indicators.

As seen from the data, Uzbekistan's energy profile is largely similar to those of Kazakhstan and Iran: an extremely high share of fossil fuels, low share of renewable sources, and an absence of nuclear energy. The experience of peer countries shows that high resource abundance does not eliminate internal risks:

- **Energy capacity and fuel shortages during peaks.** Observed in Kazakhstan, Iran, and Egypt. Uzbekistan also experienced energy deficits in recent winters.
- **Infrastructure aging.** Up to 70% of equipment in Uzbekistan has reached the end of its service life, leading to losses and accidents.
- **Concentration on one resource/partner.** Vulnerability due to natural gas dominance.
- **Climate factors.** Water shortages hindering hydropower and cooling for TPPs.

The position of Uzbekistan

Uzbekistan possesses significant reserves of natural gas, uranium, coal, and hydropower. Natural gas provides ~85% of Uzbekistan's final energy consumption. In the electricity sector, over 85% is produced at gas-fired TPPs. Until recently, industrial-scale solar and wind plants were

absent. Only in 2021–2023 did the construction of the first large SESs and VESs begin with foreign investors (Masdar, ACWA Power).

The country's energy balance was long close to zero, but growing domestic demand is reducing export potential. In the winter of 2022/23, Uzbekistan faced an acute gas shortage and was forced to stop exports and urgently import electricity. Official estimates warn that proven hydrocarbon reserves will last for 20–30 years of extraction.

Uzbekistan has approved an **Energy Development Strategy until 2030**, aiming for a 25% share of renewable energy. Simultaneously, an NPP construction program with the "Rosatom" corporation is being implemented, starting with a low-power reactor (~330 MW) in the Jizzakh region.

Recommendations for Uzbekistan

1. **Diversification of the energy balance.** Accelerate the increase of RES share to 25–30% by 2030 to reduce gas dominance. Implement nuclear generation (1–2 GW) to provide ~10–15% of stable electricity.

2. **Increased energy efficiency and infrastructure modernization.** Implement energy audits, stimulate the purchase of energy-efficient equipment, and continue price and subsidy reforms. Accelerate projects for the reconstruction of electrical and gas grids using funds from the ADB and World Bank.

3. **Development of energy storage and intelligent distribution.** Invest in battery parks and "smart grids" (smart grids). Develop underground gas storage facilities to level seasonal demand fluctuations.

4. **Strengthening regional cooperation and energy trade.** Utilize the Unified Energy System of Central Asia for seasonal exchanges (e.g., Tajik hydropower for Uzbek gas). Consider joint projects with Kazakhstan and Kyrgyzstan on water and HPP management.

5. **Diversification of fuel imports and creation of reserves.** Create strategic reserve stocks of oil and petroleum products for several months. Strengthen electricity interconnections for emergency imports.

6. **Institutional and market reforms.** Continue separating generation, transmission, and sales functions. Create a competitive wholesale electricity market. Implement strict stress tests for power plants following Japan's example.

7. **Human resource development and experience exchange.** Invest in education and retraining of personnel, focusing on RES and nuclear technologies. Strengthen cooperation with international organizations (IAEA, IEA) and continue internship programs abroad.

Conclusion

Uzbekistan is on the threshold of major transformations. Germany and China demonstrate how large-scale RES implementation can be combined with reliable supply. Japan and Egypt teach the importance of balancing sources. Applying these lessons, Uzbekistan can build an energy system resilient to internal and external challenges, ensuring long-term energy security and economic growth.

Conclusion

Uzbekistan stands at a historic crossroads. The analysis of global trends for 2024–2026 shows that a model relying solely on domestic natural gas is no longer sufficient for national security. The global energy transition and geopolitical shifts require Tashkent to adopt a **proactive and multi-vector energy policy**.

The five pillars of Uzbekistan's energy resilience are:

1. **Turkmenistan Energy Union:** Moving to joint field management and methane capture.
2. **Nuclear Renaissance:** Establishing a reliable carbon-free base load.
3. **Resource Diplomacy:** Leveraging uranium and rare earths for technology transfer.
4. **Digital Shield:** Protecting the grid via a national and regional ISAC.
5. **Institutional Reform:** Creating long-term (30–40 year) modeling centers and independent regulators.

Realizing these steps will transform Uzbekistan into a "Green Bridge" between Europe and Asia. Energy security in the 21st century is not about the resources in the ground, but the ability to manage them efficiently, protect them digitally, and integrate them into global value chains.

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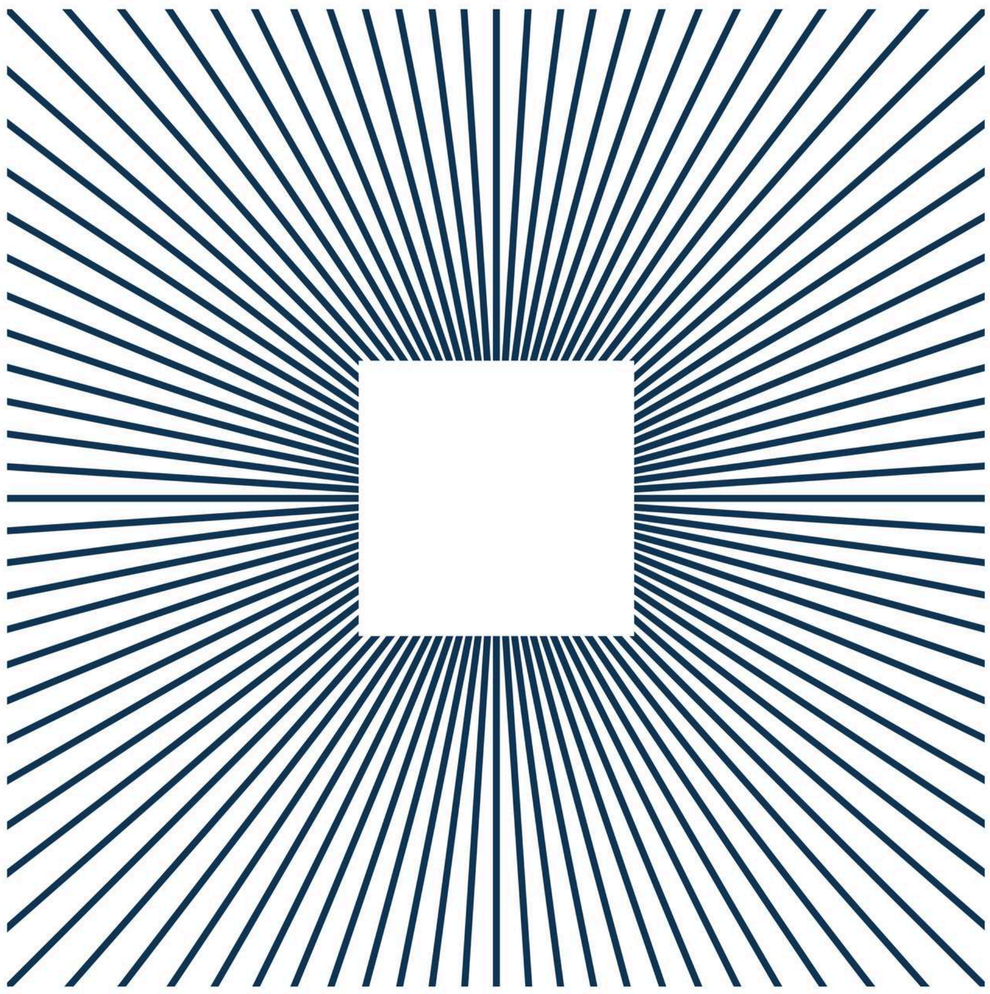

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