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Central Asia as New Battle Grounds: Critical Mineral Strategies of Kazakhstan and Uzbekistan

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Abstract

This paper examines how the energy transition may reproduce a "green resource curse" and how Kazakhstan and Uzbekistan attempt to escape it. While debates emphasize upstream ESG compliance or downstream clean-tech deployment, this paper argues the decisive arena is the midstream—smelting, refining, and separation—where value addition, quality, and supply security are set. Because midstream capacity is more concentrated than mining, mineral flows converge on bottlenecks, heightening geopolitical vulnerability and leaving resource-rich states to bear extraction costs while exporting low-value ores. Building on resource-curse political economy, the paper conceptualizes the green resource curse as a midstream capability gap that drives trade deficits, weak diversification, and new dependency under decarbonization. It then compares Kazakhstan and Uzbekistan's strategies to climb the value chain through beneficiation, state-led coordination, and external partnerships. Kazakhstan's rare earth push highlights the technical difficulty of high-purity separation, the temptation of rapid Chinese capital-technology integration, and market-access risks as U.S./EU rules of origin and sustainability standards tighten. Uzbekistan's approach centers on institutional consolidation (UzTMK), a large investment pipeline, cleaner processing initiatives, and attempts to create domestic demand through EV and battery projects. The paper identifies four conditions for avoiding a green resource curse: (1) internalizing midstream know-how, (2) reducing processing carbon intensity to meet emerging trade regimes, (3) diversifying partners to preserve flexibility, and (4) long-term institutional learning and workforce development. It concludes that Central Asia's outcomes will depend less on resource abundance than on converting strategy into midstream sovereignty.

Keywords

green resource curse, critical minerals, midstream processing, supply chain diversification, Central Asia, Kazakhstan, Uzbekistan

Introduction

The global acceleration of decarbonization is transforming mineral markets into a central arena of geopolitical and developmental contestation. As clean technologies—solar photovoltaics, wind turbines, and electric vehicles (EVs)—scale rapidly, demand for critical energy transition minerals such as lithium, nickel, cobalt, graphite, and rare earth elements (REEs) is rising sharply. Yet, the current policy conversation remains polarized. On the one hand, international debates emphasize upstream governance, focusing on mining-related environmental and human rights

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compliance. On the other, industrial strategies in major consuming economies concentrate on downstream deployment and market expansion for batteries, EVs, and renewable energy systems. Between these two poles lies the midstream stage—smelting, refining, and separation—where mined materials are converted into high-purity industrial inputs. Despite its decisive role in determining supply chain cost, quality, and security, the midstream has been systematically under-theorized and under-prioritized (International Energy Agency [IEA], 2024a; World Bank, 2023).

This gap matters because the midstream is where value is concentrated and where structural vulnerabilities are most severe. While mining is geographically dispersed across multiple regions, midstream processing capacity for key transition minerals is highly concentrated, creating an "hourglass-shaped" supply chain in which global mineral flows converge into a small number of bottlenecks. Such concentration heightens the exposure of importing countries to supply disruptions and enables strategic leverage by processing hubs. At the same time, it entrenches an asymmetric development pattern for resource-rich exporters: many states absorb extraction-related externalities—pollution, ecosystem disruption, and social conflict—while remaining excluded from high-value-added industrial segments. The resulting structure reproduces a familiar political-economy outcome: exporting low-value ores while importing high-value intermediate materials and finished clean-tech products, thereby deepening trade deficits and limiting opportunities for industrial diversification (Braunstein & Chuchko, 2025; IEA, 2023).

This paper conceptualizes this problem as a "green resource curse." Building on classic resource-curse scholarship—Dutch disease, rent-seeking, volatility, and weak institutional development—the green variant captures how the energy transition may replicate extractive dependency under a new technological regime. The curse is not reducible to mining impacts alone; rather, it is increasingly defined by whether resource-rich countries can internalize midstream capabilities and capture learning effects, employment, and technological accumulation embedded in processing industries. In this sense, "criticality" should not be measured solely by the supply-risk concerns of importing countries but also by the developmental stakes of exporting states: the capacity of mineral endowments to translate into diversification, decent work, and reduced inequality (Arezki & van der Ploeg, 2025; Ross, 2012; Sachs & Warner, 2001).

Central Asia has emerged as a particularly revealing arena for examining these dynamics. Long framed as a geopolitical corridor or a peripheral hinterland to larger powers, the region is being re-evaluated as a strategic "third zone" amid intensifying competition to diversify mineral supply chains away from existing chokepoints. Kazakhstan and Uzbekistan possess broad mineral portfolios and increasingly articulate state-led strategies aimed at upgrading from extraction toward processing and manufacturing. Their trajectories are also shaped by competing external engagement models: rapid, capital- and infrastructure-driven integration associated with Chinese industrial networks; and regulatory- and compliance-centered approaches promoted by Western initiatives focused on de-risking and ESG alignment. These models offer different trade-offs between speed, technological transfer, and long-term sovereignty over process knowledge (China Global South, 2025; European Commission, 2024b; U.S. Department of Commerce, 2025).

Against this backdrop, the paper asks three interrelated research questions. First, how does the midstream concentration of critical mineral processing reshape the mechanisms of the resource curse under decarbonization? Second, what policy instruments and institutional designs are Kazakhstan and Uzbekistan deploying to escape a low-value export trap and build midstream capacity? Third, how does intensifying great-power competition structure the opportunities and constraints for Central Asian upgrading—particularly with respect to dependence risks, market-access rules, and the prospects for technological internalization (Eurasianet, 2025a; IEA, 2024a)?

To address these questions, the paper adopts a comparative political-economy approach, tracing the evolution of critical mineral strategies in Kazakhstan and Uzbekistan and situating them within the broader governance landscape of global supply chain restructuring. It examines state policy tools (beneficiation mandates, investment programs, state-led coordinating entities), infrastructural and energy constraints, and the role of external partnerships in enabling or limiting midstream upgrading. Through this comparison, the paper argues that escaping the green resource curse requires four conditions: (1) internalizing midstream technological capabilities, especially high-purity separation; (2) reducing the carbon intensity of processing to preserve access to emerging trade regimes; (3) diversifying partners to avoid single-bloc lock-in; and (4) sustaining institutional learning and workforce development (European Commission, Directorate-General for Taxation and Customs Union, 2024; IEA, 2024a; World Bank, 2024).

The remainder of the paper is organized as follows. The next section develops the theoretical framework of the green resource curse with emphasis on midstream concentration and value capture. The following sections analyze Kazakhstan's and Uzbekistan's critical mineral strategies, highlighting their distinct institutional pathways and external partnership choices. The paper then discusses how U.S.–China competition and evolving Western regulatory frameworks shape Central Asia's upgrading space. It concludes by summarizing implications for just energy transition governance and for policy designs that convert mineral endowments into industrial transformation rather than renewed dependency.

The Evolution of the Green Resource Curse

As the adoption of clean technologies like solar panels, wind turbines, and electric vehicle (EV) batteries accelerates, demand for the critical energy transition minerals that power them—lithium, nickel, cobalt, and rare earth elements—is exploding. According to the International Energy Agency (IEA), mineral demand for the energy transition is projected to increase four to six times by 2040 compared to 2020 levels. However, current global discourse and policy efforts remain overly focused either on compliance with environmental and human rights standards during the mining (Upstream) phase or solely on expanding the deployment of final products (Downstream). Amidst this polarized debate, the critical importance of the "midstream" stage—Refining, Smelting, and Processing—which transforms mined raw materials into high-purity industrial materials, and the severe structural imbalances inherent within it, have been overlooked (IEA, 2021, 2023; World Bank, 2023).

The midstream stage is a high-value-added process that removes impurities from raw ore and processes it into the chemical state required for battery or motor manufacturing. This segment determines the quality and cost of the entire supply chain. Currently, this midstream process is concentrated in a far more extreme manner than the geographic distribution of the mining stage, being heavily skewed toward specific countries and regions. Data indicates that while mining for lithium, cobalt, rare earth elements, and others occurs across multiple continents—including Australia, the Democratic Republic of the Congo, and Chile—60% to over 90% of the capacity to refine and process these materials is concentrated in a single country or specific region. This "hourglass-shaped" supply chain structure causes global resource flows to converge at a handful of bottlenecks, creating a critical vulnerability for global energy security (IEA, 2021, 2023).

Resource-Rich Developing Countries bear the full burden of negative externalities like environmental pollution, ecosystem destruction, and social conflicts arising during the extraction phase, yet they are completely excluded from the high-value-added refining and processing stages. These nations are trapped in a trade deficit structure where they export raw materials at low prices and must then re-import high-value batteries or finished products made from those materials. This raises concerns that the exploitative economic model of the colonial era could be replicated even within a decarbonized economic system. By depriving resource-rich nations of industrialization opportunities, it hinders the achievement of the United Nations Sustainable Development Goals (SDGs), particularly reducing inequality among nations and promoting decent work and economic growth. Therefore, diversifying and restructuring the current skewed midstream structure is not merely a matter of market efficiency; it is the moral and practical responsibility of the international community for a just energy transition (Arezki & van der Ploeg, 2025; Boafo et al., 2024; United Nations, nd; World Bank, 2023).

In political economy, the resource curse is the pattern whereby countries rich in natural resources end up with: Slower, more volatile growth (Dutch disease; price booms and busts); More authoritarian and corrupt politics (rentier states); and weak institutions and limited diversification. The classic resource curse describes how countries rich in extractive resources (oil, gas, minerals) often exhibit slower long-term growth, higher inequality, weaker institutions, and more conflict than resource poor peers, despite large export revenues. Mechanisms include Dutch disease, price volatility, rent-seeking and corruption, weakened accountability, and enclave-style development that bypasses local populations (Ross, 2012; Sachs & Warner, 2001).

The green resource curse describes how the rush for critical minerals essential to clean energy technologies—like lithium, cobalt, nickel, and rare earth elements (REEs)—risks replicating the classic resource curse in developing countries, with added environmental and geopolitical twists amid the global energy transition. This manifests as economic volatility, weak diversification, authoritarian entrenchment, and severe ecological damage from mining, despite the green end-use of the materials. The green resource curse extends traditional patterns—Dutch disease, rent-seeking, volatility—to minerals powering EVs, wind turbines, solar panels, and batteries. Demand is exploding: the IEA forecasts lithium demand up 40 times by 2040 under net-zero scenarios, with similar surges for graphite, nickel, and REEs. In developing exporters (e.g., Kazakhstan, Uzbekistan, DRC, and Chile), booms create fiscal rents but often lead to currency appreciation harming non-mining sectors, elite capture, and pollution hotspots undermining climate goals (Arezki & van der Ploeg, 2025; Boafo et al., 2024; Braunstein & Chuchko, 2025; IEA, 2021; Ross, 2012).

Kazakhstan and Uzbekistan are emerging CRM (Critical Raw Materials) hubs. Kazakhstan produces 19 of the EU's 34 CRMs (expanding to 21), including REEs, chromium, tungsten. Uzbekistan leads in uranium, silver, titanium, molybdenum, and untapped lithium/REEs. EU MoUs signal diversification interest, but fossil-fueled mining (Kazakhstan 57% coal-powered) creates a sustainability paradox: green minerals extracted dirtily. Risks echo hydrocarbons: resource curse via enclave extraction, with transboundary pollution (Ember, 2024; IEA, 2023; Ross, 2012; UNECE, 2025).

China's processing dominance (copper, nickel, cobalt, REEs, lithium) exacerbates dependencies, though exploration diffuses production. China dominates the global critical minerals supply chain, processing around 90% of lithium, cobalt, nickel, graphite, and rare earths (REEs), with Central Asia emerging as a key upstream source via Belt and Road investments in Kazakhstan and Uzbekistan mining. This creates dependencies that risk entrenching green resource curses through raw ore offtake and limited local processing (Arezki & van der Ploeg, 2025; Braunstein & Chuchko, 2025; IEA, 2023).

The resource curse is not an insurmountable fate, but a matter of policy choice. Resource-rich countries in Africa and Latin America are losing 70–90% of their mineral wealth not due to a lack of mining capacity, but rather to the absence of refining and processing industries, inadequate revenue management systems, and lack of local industrial development policies. The examples of Norway ($1.4 trillion Sovereign Wealthy Fund), Botswana (the Diamond Development Model), and South Africa (the 2025 Critical Minerals Strategy) demonstrate that resource-rich countries can achieve sustainable development through strategic policies. The current surge in global mineral demand and the drive to diversify supply chains present a historic opportunity (2025–2035) for resource-rich countries, and those who leverage this opportunity can leap from low-income to upper-middle-income (Arezki & van der Ploeg, 2025; Ross, 2012; World Bank, 2023).

The policy goal is not to expand raw ore exports, but to increase the domestic production of midstream and circulation processes, including domestic smelting, refining, precursors, magnets, cathode materials, and battery recycling and to redefine the national role from a "mining exporter" to a "refining, processing, and circulation hub." Mandatory refining and processing (beneficiation policy) restricts the export of raw ore and mandates local refining and processing. Compared to raw ore, refined and chemically converted products typically command much higher unit values, because processing changes purity and chemical form and unlocks downstream manufacturing inputs. Accordingly, the economic logic of beneficiation is less about extracting more ore than about capturing value-added and learning effects in processing (Guberman et al., 2024; IEA, 2023; World Bank, 2023).

In Indonesia, due to export restrictions from 2014–2020, around nine HPAL plants are currently in operation. Following Indonesia, the Philippines plans to ban exports of nickel ore by 2030. After the government of Zimbabwe announced the refined lithium product exports to be mandated by 2027, large-scale downstream investment has been announced, including projects on the order of $400 million. Argentina has a RIGI policy which targets production of 658,000 tons of refined lithium by 2035 (up from about 75,500 tons in 2023) (Argus Media, 2025; Boafo et al., 2024; IEA, 2024a; Reuters, 2025).

As a core policy to overcome the resource curse, resource-rich countries establish a state-owned investment fund where the government manages resource revenue. The governments limit political pressure by setting spending limits (3% in Norway), enforce independent management (operated by a specialized agency separate from the government); ensure transparency (securing public trust through regular disclosure); and in long-term perspective, maintain a fund size that can withstand fluctuations in oil and mineral prices (Ross, 2012).

Central Asia as New Battle Grounds in U.S.–China Supply Chain Competition

Central Asia is rapidly emerging as a viable third zone capable of partially offsetting global dependence on China and Russia in critical mineral supply chains. Kazakhstan and Uzbekistan are not only endowed with a broad spectrum of strategic and critical minerals (Table 1), but they also serve as a geopolitical bridge between East and West. While Central Asia was previously perceived merely as Russia's backyard or a corridor for China's Belt and Road Initiative, it is now being re-evaluated as an independent strategic partner capable of enhancing the stability of global resource security. Central Asia is emerging as the new battleground against the backdrop of U.S.–China competition over critical minerals. The U.S. cannot compete with China on critical minerals, given China's dominant role in both supply chains and processing, which accounts for a large share of global processing capacity in several critical minerals. The U.S. has instead increasingly focused on securing the minerals it needs through available channels. The U.S., particularly the current administration, recognizes the vital

Table 1. Comparison of Key Critical Mineral Reserves: Kazakhstan vs. Uzbekistan

Aspect	Kazakhstan reserves focus	Uzbekistan reserves focus
Core legacy strengths	Uranium, chromite, iron ore, manganese, copper, zinc, lead, gold	Gold, copper, uranium, silver
Critical/rare metals emphasis	Uranium (as critical fuel), plus beryllium, boron, titanium, lithium, REE (lanthanoids), niobium, specialty metals tied to advanced manufacturing	Tungsten, lithium, graphite, vanadium, titanium, germanium, rhenium, broad suite of rare metals and REEs
Degree of reserve maturity	Large, well-quantified reserves in uranium and bulk metals; newer critical minerals being added to an already substantial reserve register	Many deposits identified but reserves still being quantified; significant upside from new discoveries and re-evaluation of Soviet-era rare metal and REE sites

Compiled from U.S. Geological Survey (2025), Shukurjonov (2024), and World Nuclear Association (2026).

importance of Central Asian nations. This shift in perspective reflects a reset in U.S. relations with Central Asian countries, especially Kazakhstan and Uzbekistan (Atlantic Council, 2025; Baskaran & Aubakirov, 2025; CSIS, 2025; European Council on Foreign Relations [ECFR], 2026; New Silk Road Network, 2025; Omarova, 2025).

In particular, the strategies for modernization and internalization of the refining industry pursued by Central Asian nations align closely with the supply chain diversification demands of Western countries. To escape China's environmentally destructive and opaque refining processes, Western nations seek to build transparent and eco-friendly midstream bases through technical cooperation with Central Asia. Consequently, Central Asia is moving beyond being a simple raw material supplier, seizing a historic opportunity to enter the heart of the global critical mineral value chain and secure geopolitical autonomy (Atlantic Council, 2025; ECFR, 2026; Omarova, 2025; Sagzhanov et al., 2025).

Kazakhstan is developing a "decentralized partnership" model, centered around the Alatau City project, to reduce dependence on China while maintaining geopolitical neutrality through collaboration with the EU, South Korea, and Japan. This policy innovation aims to balance supply chain resilience with geopolitical autonomy, while seeking to optimize costs, technology transfer, and regulatory compliance simultaneously (ECFR, 2026; New Silk Road Network, 2025).

Uzbekistan's critical minerals strategy emerged from global supply chain concerns over China's processing monopoly and concentrated geographic sourcing of key battery metals. Global EV battery demand is projected to rise from approximately 340 GWh in 2025 to over 3,500 GWh by 2030—roughly a tenfold increase—with lithium demand projected to increase by about one-third by 2030 to meet projected EV electrification targets. This demand explosion coincides with Western governments' heightened focus on supply chain resilience: the United States signed a Memorandum of Understanding with Uzbekistan in September 2024 for critical minerals cooperation and has invited Uzbekistan to join the Minerals Security Partnership (MSP), while the European Union formalized a Strategic Partnership on Critical Raw Materials in April 2024 (CSIS, 2025; CABAR.asia, nd; European Commission, 2024a; IEA, 2022; U.S. Department of State, 2024a, 2024b; Zakirov, 2025).

Kazakhstan has recently discovered a series of world-class rare earth deposits, emerging as a key hub in the global rare earth supply chain. As of 2025, approximately 28.2 million tons of rare earths were estimated at the Kuirektykol deposit in Karaganda Oblast, exceeding the initial estimate of 20 million tons. The Geological Commission estimated the country's total rare earth reserves at around 2.6 million tons, placing Kazakhstan among the top global holders, though this reflects registered reserves rather than forecast resources. The deposits are rich in high-demand rare earth elements, including neodymium, cerium, lanthanum, and yttrium, essential for electric vehicle motors, wind turbines, and semiconductor manufacturing. The average content is around 700 g/ton, though this remains well below China's Bayan Obo mine (30,000–60,000 g/ton, or 3–6% REO). Kazakhstan has currently identified 124 promising deposits, of which exploration has been completed at 37. Between January and September 2025 alone, the country invested approximately \$150 million in geological exploration, expanding the exploration area from 2.1 million square kilometers to 2.3 million square kilometers by end of 2025 (Atlantic Council, 2025; Karaganda Region Akimat, 2025; Reuters, 2025; The Astana Times, 2025; The Times of Central Asia, 2025).

Kazakhstan produces 19 types of rare earth elements, but they account for only 2.4% of the country's overall metals production. The biggest problem is the lack of refining and separation facilities. At present, a substantial share of rare earth ores is exported for processing abroad, primarily to China. China controls around 90% of global rare earth processing capacity, leaving Kazakhstan highly dependent on the downstream sectors of the value chain. However, Kazakhstan is a resource-rich nation, ranked first in uranium production (with a 43% global market share) and possessing extensive experience in mining key minerals such as copper and chromium. It possesses existing mineral processing infrastructure, including the Stepnogorsk Chemical Plant and the Ulba Metallurgical Plant. The SARECO joint venture has already demonstrated technology to recover neodymium and dysprosium from uranium residue (Atlantic Council, 2025; CSIS, 2025; Sagzhanov et al., 2025).

In contrast to the success in the uranium sector, clear limitations and challenges are observed in the fields of new strategic minerals such as lithium and rare earth elements (REE). The case of the Stepnogorsk facility (SARECO), established as a joint venture between the Kazakh state-owned resource enterprise Kazatomprom and Japan's Sumitomo, is representative. SARECO started ambitiously with the goal of refining and producing 5,000 to 6,000 tons of rare earth oxides (REO) annually; however, it has encountered a wall of precision technology for separating individual elements and achieving high purity during actual operations, remaining currently at the early stage of mixed rare earth extraction processes. This serves as an empirical case showing that the difficulty of refining technology in the critical mineral value chain overwhelms the difficulty of simple mining. In particular, the absence of separation technology for Heavy Rare Earth Elements (HREE)—an essential material for permanent magnets and advanced defense industries—results in Kazakhstan losing a significant portion of its added value to technology-holding countries (such as China) despite its vast reserves (IEA, 2023; The Astana Times, 2014; World Nuclear Association, 2026).

To rapidly fill these domestic technological gaps, the Kazakh government has recently been pursuing a pragmatic foreign investment attraction strategy by actively accepting Chinese capital and technology. The contract signed with Chinese companies in June 2024 to build a massive copper smelter with an annual capacity of 300,000 tons reflects the will to elevate Kazakhstan's midstream capabilities in a short period. A more notable case is Kazakhstan's first tungsten processing plant, which began operations in Almaty Province in November 2024. This project, led by Chinese capital such as Jiaxin International, involved a total investment of $300 million and is currently producing tungsten concentrate at a 65% purity level through its first-phase operation. The core of this project lies in the upcoming second phase, which aims to secure the capability to process high-purity Ammonium Paratungstate (APT) and tungsten carbide with a purity of 88.5% or higher. However, such rapid growth paradoxically suggests the risk that Kazakhstan's refining industry may be incorporated into China's supply chain vertical integration rather than achieving domestic technological independence. Consequently, Kazakhstan faces a high-level geopolitical task of maintaining its current foreign-led model while diversifying its dependence on China through technological cooperation with South Korea or Western nations (IEA, 2023; Interfax, 2024a, 2024b; The Astana Times, 2024).

The Kazakh government has defined rare earths as "new oil" and has presented a clear strategy to transform the country from a raw material exporter to a processing industry player. "Comprehensive Development Plan for the Rare Earth and Rare Metals Industry 2024–2028," adopted in 2024, encompasses expanding the resource base, modernizing production facilities, introducing new products, and restructuring the regulatory system (The Astana Times, 2025).

Kazakhstan is actively developing strategic partnerships with Western countries seeking to diversify their supply chains. Cooperation with Korea is the most concrete. In June 2024, the two countries signed a "Supply Chain Cooperation MOU," pledging to cooperate at all stages from exploration to mining, refining, and commercialization. In particular, Korean companies were granted priority participation in the development of minerals with proven economic feasibility. The Korea Institute of Industrial Technology and Satbayev University are discussing the establishment of a rare metal research center, with an investment of more than $10 million planned over 5 years. As of 2022, Korea is procuring 85% of its rare earth imports from China, making supply chain diversification a dire necessity (IEA, 2023; Invest KOREA, 2024; OECD, 2023; Reuters, 2024a).

The United States signed a Memorandum of Understanding (MOU) on critical minerals between President Tokayev and Commerce Minister Rutnik in November 2025. Cove Kaz Capital Group is negotiating the development of Kazakhstan's largest tungsten mine and is pursuing a rare earths project in the Kostanay region in a joint venture with JSC Qazgeology. The U.S. Department of Commerce is strengthening strategic cooperation, including brokering a $4.2 billion rail deal (U.S. Department of State, 2025).

The EU has invested over $200 billion since 2005, and bilateral trade is projected to reach $50 billion by 2024. The Luxembourg-based Eurasian Resources Group (ERG) contributes to the EU's Critical Minerals Partnership, supplying copper, cobalt, aluminum, and gallium. The UK signed the "Critical Minerals Cooperation Roadmap" in March 2025. Japan already operates a dysprosium plant in Stepnogorsk, producing 30–50 tons annually, supplying 10% of Japan's demand. Sumitomo and Toshiba are collaborating on molybdenum, rhenium, and beryllium extraction (Euractiv, 2025; Government of Kazakhstan, 2024; Reuters, 2012; The Astana Times, 2025; World Nuclear Association, 2026).

Uzbekistan's critical mineral portfolio positions the country as a significant player in global EV supply chains, with particular strength in copper, lithium, and tungsten reserves. Uzbekistan has positioned itself as a strategically important player in the global electric vehicle supply chain through an ambitious, state-directed critical minerals development strategy centered on a planned $2.6 billion, 3-year investment program (2025–2027) targeting 76 projects across 28 mineral elements. The

Table 2. Comparison of Critical Mineral Strategies: Kazakhstan vs. Uzbekistan

Aspect	Kazakhstan plans	Uzbekistan plans
Strategic vision	Move up from ore/export to refined products and alloys, but with more gradual, institution-dependent progress	Full chain from extraction to finished products, with state-driven industrial policy and technoparks
Concrete instruments	Exploration expansion, processing-cluster concepts, adaptation of uranium/copper/chemical plants, ESG and logistics upgrades	2.6 billion-dollar program, technoparks, labs, training centers, targeted incentives for in-country processing
REE/critical metals	Use existing nuclear and metallurgical base as platform for future REE and specialty-metal processing hubs, still early-stage and infrastructure-backed	Build new separation and high-value chemical capacity via JVs (U.S./EU/others), tied to broader manufacturing

Compiled from Eurasianet (2025b), Kun.uz (2025), The Astana Times (2025), Lex.uz (2025), and U.S. Department of Commerce (2025).

strategy prioritizes extracting, processing, and domestically manufacturing high-value products—from lithium-ion batteries to advanced alloys—rather than remaining confined to raw material exports. With reserves of over 30 critical mineral types, including lithium (approximately 178.5 thousand tons), tungsten (ranked among the top 10 globally, around 130 thousand tons), copper (among the top global holders), and extensive rare earth elements, Uzbekistan possesses the geologic foundation to support a meaningful share of global EV demand. However, the strategy faces structural constraints: China's dominance of around 90% of global rare earth processing capacity creates a bottleneck that Uzbekistan cannot overcome unilaterally; domestic processing and downstream manufacturing infrastructure remain underdeveloped; and the capital-intensive timeline for mining projects (often a decade or more from feasibility to production) creates execution risk against aggressive extraction targets. The strategy succeeds politically and diplomatically—attracting simultaneous partnership overtures from the U.S., EU, and China—but its economic viability hinges on whether Uzbekistan can overcome processing infrastructure gaps and establish bankable financing models for 76+ concurrent projects (Associated Press, 2025; Eurasianet, 2025b; Shukurjonov, 2024; U.S. Department of Commerce, 2025).

For Uzbekistan, this timing represents both opportunity and necessity. Historically, the country maintained strict state control over mineral extraction with limited foreign investment, confining the sector to basic copper and zinc production through state enterprises like AGMK and NGMK. Under President Shavkat Mirziyoyev's post-2016 economic liberalization agenda, the government reversed course: the 2024 "On Subsoil" law opened more than 50 mineral deposits to foreign investors, and institutional reforms created new state-led entities to accelerate development and manage investor relationships. The critical minerals strategy thus represents both a consolidation of state power (through the newly established Uzbekistan Technological Metals Complex, or UzTMK) and a pragmatic embrace of foreign capital, technology, and partnerships (U.S. Department of Commerce, 2025; UNECE, 2025) (Table 2).

The government established the Uzbekistan Technological Metals Complex (UzTMK) in 2024 as a subsidiary of the State Atomic Company (AMMC), centralizing all state-owned critical minerals assets under one entity. This consolidation model reflects a deliberate policy shift toward integrated value-chain management—managing mining, processing, and manufacturing as coordinated activities rather than siloed operations. UzTMK's stated mission extends beyond extraction: the organization positions itself as a vertically integrated producer capable of delivering high-purity metals and finished goods aligned with global sustainability standards (ESG/IRMA compliance) (UzTMK, 2024).

The key policy instrument is the $2.6 billion, 3-year investment program announced by President Mirziyoyev on March 7, 2025, covering 76 projects across 28 mineral elements. The Ministry of Mining Industry and Geology, reorganized and strengthened under recent reforms, manages permitting and regulatory oversight. The Uzbekistan Reconstruction and Development Fund (URDF) has committed $220 million in equity financing to UzTMK, ensuring state backing for project implementation (Eurasianet, 2025b; U.S. Department of Commerce, 2025).

This institutional design prioritizes state control of extraction while delegating downstream processing and manufacturing to foreign joint ventures and technology partners—a pragmatic compromise between nationalist resource control and the capital and expertise required for competitive global production (U.S. Department of Commerce, 2025) (Table 3).

Uzbekistan is simultaneously developing domestic EV manufacturing, creating parallel demand for critical minerals within its borders. BYD-UzAuto Joint Venture (Jizzakh Plant) with UzAuto holding 60% and BYD 40%, began production in January 2024 and targets up to 50,000 vehicles annually. In 2024, BYD Uzbekistan sold 17,000 electric vehicles, making it the second-largest EV seller in the country by volume (after imports). Asaka Motors International, a smaller-scale producer, focuses on

Table 3. Comparison of Infrastructure for Mineral Supply Chains: Kazakhstan vs. Uzbekistan

Category	Kazakhstan	Uzbekistan
Transport corridors	TITR/Middle corridor hub; KTZ rail expansions to Uzbekistan/Europe	Trans-caspian upgrades (€1.5bn EBRD); road/rail for export nodes
Power/energy	Existing hydro/thermal for mining; competitive energy for processing.	$910mn grid/water upgrades; renewables to cut outages
Site-specific mining	Tailings reprocessing; Soviet plants adapted for REE and alloys	$90mn navoi ore projects; UzTMK tech hubs (Tashkent/Samarkand)

Compiled from OECD (2023), European Bank for Reconstruction and Development (2024), Jamestown Foundation (2025), World Bank (2020), and Trend News Agency (2026).

assembly and localization of Geely electric vehicles with plans to expand EV production capabilities. In September 2025, Asaka Motors and Rosatom's Fuel Division signed a cooperation agreement to localize production of traction batteries for electric vehicles and stationary energy storage systems in Uzbekistan, with plans to explore export markets to Central Asia and beyond. RENERA (Russia's leading battery manufacturer) has also entered discussions with Uzbekistan's Uzeltekhsanoat association regarding joint production facilities, technology transfer, and workforce training (IEA, 2024b; Kun.uz, 2025; S&P Global Ratings, 2025; Uzeltekhsanoat, 2025).

These initiatives create a domestic demand pull for lithium, cobalt, nickel, and manganese—effectively allowing Uzbekistan to vertically integrate from raw extraction through finished vehicle production, capturing substantially greater value than raw material export models (IEA, 2024b) (Table 4).

Uzbekistan's tungsten strategy exemplifies the government's broader approach to transforming from commodity extraction into finished product manufacturing. At mining stage, the Ingichka tungsten deposit (Samarkand region) undergoes dual development. Partnership with China's Xinhai focuses on tungsten recovery from mining waste, targeting 1,050 tons of concentrate and $18.4 million in projected revenues. A separate joint project with Turkey's International Gold Madencilik at the Sautbay deposit aims to produce 4,811 tons of concentrate. As a processing stage, a new hydrometallurgical facility in the Samarkand region (designed with engineering input from Canada, Australia, Finland, and Turkey) will process tungsten concentrate: 5,000 tons by 2027, scaling to 15,000 tons by 2030, generating over $300 million in value for processed products. For downstream manufacturing, UzTMK is already producing finished tungsten products (briquettes, ingots, carbide drill bits, milling tools, electrodes) for export to Europe and the United States, with expansion into Japanese and South Korean markets underway (Minex Forum, 2025; UzTMK, 2025b).

Uzbekistan is endeavoring to avoid the green resource curse by preemptively managing environmental pollution risks that may arise during the expansion of the refining industry. A key example is the introduction of the Closed-loop Soda Leaching System pursued at the Technological Metals Complex (TMK). This system is an innovative process that reduces ammonia consumption by 4.4 times compared to conventional methods and recirculates harmful emissions without discharging them externally. Through this, Uzbekistan plans to secure eco-friendly molybdenum processing technology—a first in Central Asia—thereby lowering export barriers to global markets with strict environmental regulations, such as Europe, and gaining recognition for the Green Premium value of its products (UzTMK, 2025a).

To respond to the electric vehicle era, Uzbekistan is also accelerating its efforts in the lithium refining sector. The Nurlikon lithium project, which aims to establish a production facility for 14,000 tons of lithium carbonate per year by 2026, is the cornerstone of building Uzbekistan's battery supply chain. For this purpose, the government plans to invest a massive total of $2.6 billion over the next 3 years to promote 76 mineral refining and processing projects. Furthermore, through technoparks being established in major cities like Tashkent, the country is striving to escape technological dependence on foreign powers by vertically integrating entire processing systems, ranging from semiconductor materials to powder metallurgy (Eurasianet, 2025b; Shukurjonov, 2024).

Uzbekistan's most distinctive strategy is to reduce the dependence on Chinese capital and enhance technological self-sufficiency through close technical cooperation with South Korea and the United States. The Uzbek-Korea Rare Metals Center, established with technical support from the Korea Institute of Industrial Technology (KITECH) and the Korea Institute of Geoscience and Mineral Resources (KIGAM), currently possesses world-class research capabilities for extracting and refining 28 types of minerals. This center serves as an outpost for technological sovereignty, supporting the entire process from raw ore analysis to the design of high-purity separation processes in Uzbekistan (Donga Science, 2019; Lex.uz, 2025).

Additionally, the U.S.–Uzbekistan Business and Investment Council, established by presidential decree in November 2025, serves as an institutional platform for

Table 4. Value-Chain Readiness for Strategic Industrial Minerals: Kazakhstan vs. Uzbekistan

Value chain	Kazakhstan focus & readiness	Uzbekistan focus & readiness
Li-ion batteries	Manganese sulfate (Tesla OK), graphite (Sarytogan), nickel/cobalt/phosphorites; processing underway; most advanced	Lithium extraction (nurlikon), graphite/vanadium potential; tech parks for processing; early-stage, extraction-heavy
NdFeB magnets	Neodymium/praseodymium (Akbulak), magnet recycling (Ulba); gallium; processing/recycling operational	REE deposits (navoi, Nd/Dy); bilateral REE partnership; exploration/JV phase
Superalloys	Rhenium recycling, nickel alloys (EU JVs); established recycling/alloy base	Tungsten (10 kt + oxide, TMK), molybdenum (eco-processing), beryllium; scaling production

Compiled from Reuters (2024a), Shukurjonov (2024), Minex Forum (2025), UzTMK (2025a, 2025b), Qazinform (2025), and Sarytogan Graphite Limited (2024).

attracting advanced refining technologies from U.S. firms and embedding ESG management practices. Taken together, these initiatives indicate that Uzbekistan is evolving from a resource-exporting economy toward a midstream-oriented industrial hub built on domestically anchored refining capabilities and diversified international partnerships (Lex.uz, 2025; U.S. Department of Commerce, 2025).

International Partnerships and Cooperation Systems

The geopolitical landscape surrounding Uzbekistan's rare earth industry is complex. China is rapidly advancing into the development of Uzbekistan's key mineral resources. In 2024, China's Limaomaori Metals established a mine in Parkent, Tashkent region. The Surenata mining complex is under construction, with an annual capacity of 2.4 million tons of ore and 1 million tons of iron ore concentrate. China Baoli Technology is constructing a non-ferrous metals plant with an annual production capacity of 18,000 to 45,000 tons in the Yuli Free Economic Zone with an investment of \$200 million, with an export potential of \$18 million (China Global South, 2025; Eurasianet, 2025b; Ministry of Mining Industry and Geology of Uzbekistan, 2024).

In August 2025, China State Gold Group signed an agreement with Uzbekistan to expand cooperation in geological exploration for precious metals and key minerals. This aggressive investment reflects China's strategic goal of securing a source of minerals it relies on imports, such as copper and iron ore, and its geopolitical intention to counter Western attempts to diversify its supply chain (Eurasianet, 2025a).

Kazakhstan has the potential to emerge as a key supplier in the global rare earths supply chain, leveraging its strengths: the potential to become one of the world's leading rare earth holders pending independent verification of its reserve estimates, uranium and copper mining experience, geopolitical neutrality, and access to both Eastern and Western markets. Kazakhstan's strategic value is particularly significant as China tightens its rare earths export restrictions and Western countries prioritize supply chain diversification (Atlantic Council, 2025; IEA, 2025b).

Moreover, integration into China-dominated supply chains carries geopolitical implications. As Western regulatory frameworks—such as the U.S. Inflation Reduction Act (IRA) and the EU Critical Raw Materials Act (CRMA)—increasingly scrutinize supply chain origin and ownership structures, Central Asian projects heavily embedded in Chinese capital and technology networks may face market-access constraints. Thus, the same integration that accelerates industrialization could simultaneously limit diversification into Western markets (European Commission, 2024b; Korea Economic Institute of America, 2025).

In this sense, the Chinese vertically integrated model offers speed and scale but poses structural risks of dependency. It mitigates short-term industrial gaps while potentially reinforcing long-term governance asymmetries. For Central Asian states attempting to escape the green resource curse, the core challenge is not simply attracting investment, but ensuring that technological upgrading accompanies physical industrial expansion (IEA, 2024a).

In response to China's consolidation of critical mineral supply chains, the United States and its partners have advanced a strategy centered on de-risking and regulatory alignment. Initiatives such as the Mineral Security Partnership (MSP) seek to mobilize capital for projects that meet stringent environmental, social, and governance (ESG) standards. Financial instruments—including development finance guarantees and risk-sharing mechanisms—aim to support non-Chinese supply chains. This approach prioritizes transparency, environmental compliance, and market-based governance. It seeks to integrate Central Asian mineral production into Western-aligned supply chains through adherence to high regulatory standards. By emphasizing ESG compatibility, the model attempts to prevent environmentally destructive extraction practices and reduce geopolitical vulnerability (U.S. Department of State, 2024a, 2024b).

However, the Western engagement model faces two structural constraints. First, it often emphasizes financial de-risking rather than embedded technological transfer. While capital mobilization and regulatory alignment are essential, they do not automatically generate domestic midstream capacity. Without targeted support for process engineering, separation technology, and refining expertise, regulatory compliance alone cannot ensure industrial upgrading (CSIS, 2025).

Second, the high standards and conditionalities associated with Western engagement may slow project implementation in contexts where administrative capacity and infrastructure remain under development. For Central Asian governments seeking rapid industrialization and revenue diversification, the pace and procedural complexity of Western frameworks may appear misaligned with immediate economic priorities (European Commission, 2024b).

From a political-economy perspective, the Western model represents a regulatory-heavy governance approach. It addresses environmental and transparency risks central to the green resource curse but may insufficiently engage with the technological dimension of midstream sovereignty. In other words, it seeks to ensure that extraction and processing are clean and compliant, yet may not fully address who controls the knowledge and industrial learning embedded in refining processes (CSIS, 2025).

Consequently, while Western initiatives contribute to supply chain diversification and normative upgrading, they leave a strategic space between capital-intensive Chinese integration and compliance-driven Western engagement. This intermediate space is where alternative partnership models may emerge (CSIS, 2025).

South Korea's expansion into Central Asia stems from structural necessity. As of 2025, South Korea is extremely dependent on mineral imports, reaching 99.7%, with over 82% of these coming from China, meaning that the strategic lifeline of South Korean industries—encompassing semiconductors, batteries, and hydrogen—is heavily dependent on Chinese supply chains. President Yoon Suk Yeol's 2024 Central Asian tour, the launch of the K-Silk Road program, and his assumption of the Mineral Security Partnership (MSP) chairship in July 2024 reflect South Korea's strategic choice in responding to this crisis. Through these initiatives, South Korea is seeking to redefine its role from simply a mineral buyer to a leading player in restructuring mineral supply chains. South Korea occupies a unique position in Central Asia; amidst Chinese capital that offers limited technology transfer, U.S. policy platforms with limited direct investment, and Middle Eastern giants lacking long-term technological dominance, South Korea seeks to differentiate itself as a trusted technology partner and neutral intermediary. The government's response strategy is multi-layered and consistent, setting a target to reduce dependence on mineral imports by 50% by 2030, establishing an 8-day emergency response system, supporting private overseas mining through public loans, insurance, and tax subsidies, and strengthening domestic resource recycling capacity. Within this strategic context, Central Asia offers a triple advantage: geographic proximity within 2,000 km, abundant resources including copper, lithium, uranium, and rare earths, and the critical status of being outside China's exclusive control, thereby heralding the beginning of a new era of economic diplomacy through the K-Silk Road program (CSIS, 2025; Korea Economic Institute of America, 2025; Ministry of Foreign Affairs of the Republic of Korea, 2024; Reuters, 2024b; Yonhap News Agency, 2023).

The K-Silk Road program is structured around three strategic priorities, beginning with the critical task of securing raw materials and essential minerals. In Kazakhstan, cooperation centers on the exploration of copper, rare earths, and uranium, alongside South Korea's participation in a nuclear power consortium. Collaboration with Uzbekistan focuses on lithium development at the Nurlikon mine, as well as tungsten and rare earth extraction and refining technologies. Meanwhile, engagement with Turkmenistan aims at expanding gas cooperation and linking energy refining industries, while Tajikistan involves a $26 million investment in initial geological exploration and training programs covering 76 mineral projects (Reuters, 2024b; Yonhap News Agency, 2024).

The second priority involves the expansion of transportation and logistics infrastructure to facilitate trade. A landmark $196 million order for Hyundai Rotem's high-speed trains in Uzbekistan, signed in June 2024, serves as a cornerstone for establishing the K-Silk Road Logistics Corridor, designed to transport Central Asian minerals to South Korean and ASEAN markets. Parallel to this, the third priority focuses on green energy technology cooperation. This includes renewable energy education programs led by the Korea Energy Agency, which has trained 258 Uzbek energy experts since 2021, with an additional 100 expected by 2025 (Korea Herald, 2025; Yonhap News Agency, 2024).

Beyond state-level diplomacy, economic integration is being driven by private investment, with approximately 460 to 500 Korean companies, including KT&G and various construction firms, operating in Uzbekistan. A significant milestone in this sector is the $3.1 billion YPP Green Hydrogen Project in Kazakhstan, marking South Korea's largest renewable energy investment in the region. Furthermore, the March 2025 Memorandum of Understanding between Korea Hydro & Nuclear Power (KHNP) and Kazakhstan's Al-Farabi University aims to develop cutting-edge technology for extracting uranium from seawater and groundwater. This technological frontier is particularly vital as it offers a structural solution to South Korea's uranium supply—more than 95% of which is currently imported—while leveraging Central Asia's role as a global nuclear fuel powerhouse. By applying KHNP's proprietary adsorbent technology, South Korea not only secures a permanent supplier but also asserts its leadership in a high-tech field competing with the United States and Japan. Before identifying Korea's unique role in Central Asian mineral governance, it is essential to acknowledge the structural constraints and competitive disadvantages that South Korea faces compared to major global powers (CSIS, 2025; IEA, 2025a; Kazakh Invest, 2025; National Statistics Committee of the Republic of Uzbekistan, 2026; World Nuclear News, 2025).

South Korea faces significant hurdles, including a substantial capital disparity—with its total investment

Table 5. South Korea's Import Dependence on China for Strategic Critical Minerals

Key minerals	Dependence on China (%)	Main uses	Alternative suppliers
Natural graphite	97.7	Batteries, semiconductors	None (supply diversification impossible)
Synthetic graphite	94.3	Battery positive electrode	Japan, Canada (small quantities)
Cobalt oxide	83.3	Battery positive electrode material	Congo, Indonesia
Lithium oxide	81.2	Battery core components	Australia, Chile, Argentina
Manganese	77.6	Battery, steel	Gabon, Australia (partially)

Compiled from Chambers and Partners (2024), and Yonhap News Agency (2022).

representing only about 25% of China's—and a relative lack of geopolitical hard power to influence regional policy decisions directly (Table 5). Furthermore, the reverse dependency in logistics and final market demand means that Korea's securing of minerals does not automatically guarantee supply chain autonomy. However, these strategic weaknesses do not imply a lack of competitiveness. Instead, they serve as a critical driver for Korea to abandon capital-intensive, infrastructure-led competition in favor of a more specialized and qualitative approach. By recognizing that it cannot compete on the scale of absolute capital or political coercion, South Korea has pivoted toward a Process-Embedded Industrial Partnership Model. This model leverages Korea's world-class midstream technological expertise to offer something that neither the Chinese nor Western models fully prioritize: the systemic transplantation of process sovereignty and technical autonomy to host nations. The potential contribution of Korea lies exactly in this niche—shifting the focus from resource extraction to industrial internalization. Unlike capital-dominant integration, this approach emphasizes the transplantation of entire processing systems (CSIS, 2025; World Bank, 2024).

South Korea occupies a distinctive position within this evolving geopolitical landscape. As a late industrializer that achieved rapid upgrading without significant domestic resource endowments, Korea developed deep capabilities in midstream processing industries—petrochemicals, battery materials, specialty metals, and advanced manufacturing components. This historical trajectory positions it as a process-intensive industrial state rather than a resource-dominant or capital-surplus power (World Bank, 2024).

Korea's potential contribution to Central Asia lies in what may be termed a process-embedded industrial partnership model. Unlike capital-dominant integration models, this approach emphasizes the transplantation of entire processing systems: laboratory-scale testing, pilot plant design, high-purity separation techniques, metallurgical optimization, and workforce training. The objective is not merely to build facilities, but to internalize process knowledge within domestic institutions (CSIS, 2025; World Bank, 2024).

The Uzbekistan–Korea Rare Metals Center provides an illustrative example of such embedded cooperation. By combining geological analysis, separation technology design, and applied research collaboration, the partnership seeks to support local capacity development across the value chain. This contrasts with arrangements in which equipment is imported and operated without full diffusion of underlying expertise (CSIS, 2025).

Korea's role is also shaped by its position as a middle power navigating between major blocs. It does not impose extensive political conditionalities comparable to some Western frameworks, nor does it pursue comprehensive vertical integration of foreign industrial bases. Instead, it can operate as an institutionally complementary partner—aligning with global ESG norms while focusing on technical problem-solving and incremental upgrading (CSIS, 2025; World Bank, 2024).

Crucially, the green resource curse is increasingly defined by midstream capability gaps rather than upstream extraction constraints. Escaping this curse requires internalizing high-value segments of the critical mineral value chain, reducing carbon intensity in processing, and diversifying supply chain linkages. Korea's expertise in battery materials, advanced metallurgy, and carbon-efficient industrial processes directly addresses these dimensions (European Commission, 2024b; World Bank, 2024).

Furthermore, Korea's own exposure to supply chain vulnerabilities—particularly in rare earths and battery materials—creates mutual incentives. Rather than a purely extractive partnership, cooperation can take the form of joint ventures, technology co-development, and shared access to downstream markets. This reciprocity reduces the risk that Central Asian states become subordinate nodes in externally governed networks (CSIS, 2025; World Bank, 2024).

In geopolitical terms, Korea can also facilitate triangular cooperation frameworks. By combining Western financial instruments with Korean process engineering and Central Asian resource endowments, hybrid governance models may emerge. Such arrangements diversify dependency risks and reduce the probability of technological lock-in to a single hegemonic system (CSIS, 2025; World Bank, 2024).

On August 9, 2024, more than 450 Central Asian representatives and over 100 major Japanese companies gathered in Astana. The August 2024 Astana Forum was a signal that "Japan is seriously pursuing Central Asia." (Omirgazy, 2024).

In December 19–20, 2025, the "Central Asia + Japan Summit" held in Tokyo by Prime Minister Sanae Takaichi signifies a paradigm shift in Japanese diplomacy. At the summit, Japan upgraded cooperation with the five Central Asian countries to a "strategic economic partnership" and pledged to invest ¥3 trillion ($19 billion) in business projects over the next 5 years (Ministry of Foreign Affairs of Japan, 2025).

This is not simply a financial pledge, but a clear signal that Japan intends to make Central Asia a focal point of its energy security and mineral supply strategy. Japan is 100% dependent on mineral imports. Unlike South Korea's "multi-vector brokerage strategy" or the United States' "policy leadership," Japan is entering the Central Asian market armed with "technological depth and long-term institutional strength" (Agency for Natural Resources and Energy, 2020; Ministry of Foreign Affairs of Japan, 2025).

The analysis above suggests that avoiding a green resource curse in Central Asia requires more than resource abundance or capital inflows. Four interrelated conditions appear critical:

(1) Midstream Technological Internalization – Acquisition of high-purity refining and separation capabilities. (2) Carbon Intensity Reduction – Alignment with emerging trade regimes such as CBAM to preserve market access. (3) Supply Chain Diversification – Avoidance of single-bloc integration that limits geopolitical flexibility. (4) Institutional Learning and Workforce Development – Long-term absorption of industrial knowledge.

China's model strongly supports rapid infrastructure and processing expansion but risks technological lock-in. Western approaches strengthen regulatory alignment but may insufficiently embed industrial learning. Korea's process-embedded partnership model addresses the technological dimension of upgrading while maintaining flexibility across geopolitical blocs (CSIS, 2025; World Bank, 2024).

For Central Asia, the strategic challenge is therefore not choosing between great powers, but structuring partnerships that maximize technological sovereignty while minimizing dependency. The region's ability to convert mineral wealth into sustainable industrial transformation will depend on how effectively it navigates this complex governance landscape (World Bank, 2024).

In this broader context, South Korea's role is not hegemonic but catalytic. By enabling process-level capability development and facilitating integration into diversified markets, it can contribute to a development trajectory in which critical mineral wealth becomes a foundation for industrial upgrading rather than a new iteration of resource dependency (CSIS, 2025; World Bank, 2024).

Conclusion

This paper has argued that the accelerating global energy transition risks reproducing a new form of extractive dependency—the green resource curse—unless resource-rich countries can internalize the midstream segments of critical mineral value chains. Moving beyond conventional debates that prioritize upstream ESG compliance or downstream clean-technology deployment, the analysis has shown that smelting, refining, and separation constitute the decisive arena in which value, power, and vulnerability are concentrated. The extreme geographic concentration of midstream capacity creates hourglass-shaped supply chains that simultaneously expose importing economies to strategic chokepoints and lock exporting states into low-value, high-externality roles.

Through a comparative political-economy analysis of Kazakhstan and Uzbekistan, the paper demonstrates that escaping this trap is neither automatic nor purely market-driven. Both countries possess abundant mineral endowments and increasingly articulate state-led strategies aimed at beneficiation, industrial upgrading, and value-chain internalization. Yet, their trajectories reveal distinct constraints. Kazakhstan's experience highlights the technological difficulty of high-purity separation—particularly for heavy rare earth elements—and the geopolitical risks of rapid integration into China-centered processing networks, which may accelerate capacity expansion while limiting technological sovereignty and market access under tightening Western regulatory regimes. Uzbekistan's approach illustrates a more centralized and programmatic attempt to coordinate extraction, processing, and manufacturing through institutional consolidation and large-scale investment, while simultaneously confronting execution risks related to infrastructure, financing, and technological absorption.

The findings suggest that the green resource curse is increasingly defined not by extraction capacity but by midstream capability gaps. Four conditions emerge as critical for overcoming this constraint: (1) the internalization of processing and separation technologies that enable learning effects and industrial spillovers; (2) the reduction of carbon intensity in refining processes to maintain access to emerging trade regimes and carbon border measures; (3) diversification of external partnerships to avoid single-bloc dependency and preserve geopolitical flexibility; and (4) sustained institutional learning through workforce development and domestic research capacity. Where these conditions are absent, mineral booms risk reinforcing volatility, dependency, and unequal value capture—even within a decarbonized global economy.

Within this evolving governance landscape, the paper has highlighted the distinctive role that middle powers such as South Korea can play. Unlike capital-dominant integration models or compliance-driven regulatory frameworks, Korea's process-embedded industrial partnership model emphasizes the transfer of operational know-how, pilot-scale experimentation, and workforce training alongside physical investment. This approach addresses the technological core of midstream sovereignty while remaining compatible with global ESG norms and diversified market access. For Central Asia, such partnerships offer a pathway to convert mineral abundance into industrial upgrading rather than renewed dependency.

More broadly, the analysis contributes to debates on just energy transition governance by reframing critical minerals not merely as inputs for decarbonization, but as determinants of developmental trajectories. Whether Central Asia becomes a peripheral extraction zone or an integrated processing and circulation hub will depend on how effectively states structure partnerships, manage technological learning, and align industrial policy with geopolitical realities. The green resource curse is therefore not an inevitable outcome of mineral abundance, but a contingent result of policy choice, institutional design, and the governance of midstream capabilities.

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