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FINANCIAL MANAGEMENT AND RISK MANAGEMENT STRATEGIES IN THE FUEL AND ENERGY COMPLEX UNDER INNOVATIVE DEVELOPMENT

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Abstract. This article examines financial management and risk management issues in Kazakhstan's fuel and energy complex (FEC) under conditions of innovative development. The relevance of the study stems from the FEC's critical role in Kazakhstan's economy and the need to ensure its sustainability amid volatile global markets and a national push for innovation. The working hypothesis is that by applying modern financial planning tools, scenario-based risk analysis, and diversification strategies, both external and internal risks in the FEC can be effectively managed without undermining innovative growth. The research methodology includes a review of recent literature by Kazakhstani and international scholars, analysis of industry data from the last five years, and scenario modeling of financial outcomes under varying conditions. Key findings indicate that Kazakhstan's FEC faces significant risks due to heavy dependence on oil and gas and exposure to global price volatility. Aging infrastructure – with major power plants averaging 40–55 years old and over half of equipment worn out– further exacerbates operational risks. Nevertheless, scenario analysis shows that implementing financial risk mitigation (such as hedging and maintaining sovereign savings) and investing in innovation (such as renewable energy, which grew to 6.4% of electricity generation by 2024) can improve the FEC's resilience. The study concludes with recommendations including sectoral diversification, improved corporate governance, and strategic use

of financial buffers. These measures can be applied in practice by policymakers and energy enterprises to enhance energy security and support sustainable, innovation-driven development.

Keywords: financial management; risk management; fuel and energy complex; innovative development; diversification; energy security

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ИННОВАЦИЯЛЫҚ ДАМУ ЖАҒДАЙЫНДА ОТЫН-ЭНЕРГЕТИКАЛЫҚ КЕШЕНДЕГІ ҚАРЖЫЛЫҚ БАСҚАРУ ЖӘНЕ ТӘУЕКЕЛДЕРДІ БАСҚАРУ СТРАТЕГИЯЛАРЫ

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Аннотация. Мақалада Қазақстанның отын-энергетикалық кешеніндегі (ОЭК) қаржылық менеджмент пен тәуекелдерді басқару мәселелері инновациялық экономикаға көшу жағдайында қарастырылады. Зерттеудің өзектілігі ел экономикасындағы ОЭК-тің негізгі рөлімен және жаһандық нарықтардың құбылмалылығы мен инновациялық даму бағыты жағдайында саланың тұрақты жұмыс істеу қажеттілігімен айқындалады. Жұмыстың гипотезасы заманауи қаржылық жоспарлау құралдарын, тәуекелдердің сценарийлік талдауын және әртараптандыру стратегияларын қолдану ОЭК-тегі ішкі және сыртқы тәуекелдерді инновациялық өсімге зиян келтірмей тиімді басқаруға мүмкіндік береді деген тұжырымға негізделеді. Зерттеудің әдіснамалық негізі қазақстандық және шетелдік авторлардың заманауи ғылыми еңбектеріне шолу жасауды, соңғы бес жылдағы салалық деректерді талдауды және әртүрлі макроэкономикалық сценарийлер жағдайында қаржылық-экономикалық көрсеткіштердің сценарийлік модельдеуін қамтиды. Зерттеу нәтижелері Қазақстанның ОЭК-і мұнай-газ секторының жоғары үлесіне байланысты айтарлықтай тәуекелдерге тап болып отырғанын көрсетеді: елдің жалпы ішкі өнімінің шамамен үштен бірі мұнай мен газ табыстары есебінен қалыптасады, ал отын тауарлары экспорттың 60%-ына дейінгі үлесін құрайды. Энергия ресурстарына бағаның құбылмалылығы қаржылық тұрақтылыққа

қауіп төндіреді. Инфрақұрылымның тозуы да тәуекелдерді күшейтеді: электр станцияларының негізгі жабдықтарының шамамен 57%-ы пайдалану мерзімінің шегіне жеткен, электр желілерінің тозу деңгейі 66%-ды құрайды, ал электр энергиясының шығыны 11%-ға дейін жетеді. Сценарийлік талдау тәуекелдерді қаржылық сақтандыру шараларын (мысалы, баға құбылмалылығын хеджирлеу, Ұлттық қор қаражатын пайдалану) және инновацияларға инвестиция салуды (2024 жылы электр энергиясын өндіруде жаңартылатын энергия көздерінің үлесі 6,4%-ға жеткен) іске асыру ОЭК-тің тұрақтылығын арттыратынын көрсетті. Мақалада саланы әртараптандыру, жаңартылатын энергия көздерін дамыту, ұзақ мерзімді қаржылық жоспарлау мен корпоративтік басқару жүйесін жетілдіру бойынша ұсыныстар тұжырымдалған. Осы шараларды жүзеге асыру Қазақстанның энергетикалық қауіпсіздігін нығайтып, саланың инновациялық негізде тұрақты дамуын қамтамасыз етуге мүмкіндік береді, ал алынған нәтижелерді мемлекеттік органдар мен салалық компаниялар тәжірибе жүзінде қолдана алады.

Түйін сөздер: қаржылық менеджмент; тәуекелдерді басқару; отын-энергетикалық кешен; инновациялық даму; әртараптандыру; энергия қауіпсіздігі

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ФИНАНСОВОЕ УПРАВЛЕНИЕ И СТРАТЕГИИ УПРАВЛЕНИЯ РИСКАМИ В ТОПЛИВНО-ЭНЕРГЕТИЧЕСКОМ КОМПЛЕКСЕ В УСЛОВИЯХ ИННОВАЦИОННОГО РАЗВИТИЯ

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Аннотация. В статье исследуются проблемы финансового менеджмента и управления рисками в топливно-энергетическом комплексе (ТЭК) Казахстана в условиях перехода к инновационной экономике. Актуальность обусловлена ключевой ролью ТЭК в экономике страны и необходимостью обеспечения устойчивого функционирования отрасли в условиях волатильности мировых рынков и курса на инновации. Рабочая гипотеза заключается в том, что

применение современных инструментов финансового планирования, сценарного анализа рисков и стратегий диверсификации позволит эффективно управлять внешними и внутренними рисками в ТЭК без ущерба для инновационного роста. Методологическая база исследования включает обзор современных научных источников казахстанских и зарубежных авторов, анализ отраслевых данных за последние пять лет, а также сценарное моделирование финансово-экономических показателей при различных макроэкономических сценариях. Результаты исследования показывают, что ТЭК Казахстана сталкивается со значительными рисками вследствие высокой зависимости от нефтегазового сектора: до трети ВВП страны формируется за счет доходов от нефти и газа, а на топливные товары приходится до 60% экспорта. Волатильность цен на энергоносители создает угрозу финансовой стабильности. Износ инфраструктуры усугубляет риски: около 57% основного оборудования электростанций достигло предельного срока эксплуатации, износ электросетей составляет 66%, а потери электроэнергии достигают 11%. Сценарный анализ показывает, что реализация мер по финансовому страхованию рисков (например, хеджирование ценовых колебаний, использование накоплений Национального фонда) и инвестиции в инновации (доля возобновляемых источников энергии в производстве электроэнергии достигла 6,4% в 2024 г.) повышают устойчивость ТЭК. В статье сформулированы рекомендации, включающие диверсификацию отрасли, развитие возобновляемых источников энергии, совершенствование системы долгосрочного финансового планирования и корпоративного управления. Таким образом, реализация данных мер позволит укрепить энергетическую безопасность Казахстана и обеспечить устойчивое развитие сектора на инновационной основе, а полученные результаты могут быть практически использованы государственными органами и компаниями отрасли.

Ключевые слова: финансовый менеджмент; управление рисками; топливно-энергетический комплекс; инновационное развитие; диверсификация; энергетическая безопасность

Introduction. Kazakhstan's fuel and energy complex (FEC) plays a pivotal role in the national economy and is a major driver of industrial growth. The FEC encompasses the oil, natural gas, coal, and power industries, which collectively provide a substantial share of government revenues, export earnings, and employment. However, the sector's heavy reliance on hydrocarbons also represents a source of vulnerability. Oil and gas revenues account for roughly 35% of Kazakhstan's GDP and about 75% of export earnings in recent years. In 2023, fuel (oil and gas) exports alone comprised 59% of the country's merchandise exports, underscoring low diversification. This dependence makes the economy and energy sector highly sensitive to external shocks such as commodity price fluctuations. Indeed, global oil price volatility in the last five years has been extreme: Brent crude prices collapsed from an average of over $60 in 2019 to about $42 in 2020 amid the COVID-19 crisis,

then rebounded sharply to $71 by 2021 and spiked above $100 in 2022, before easing to ~$82 in 2023. Such swings in oil prices translate into corresponding swings in export revenues and fiscal receipts, complicating financial management in the FEC.

Another significant external risk factor is transit and geopolitical exposure. Kazakhstan is a landlocked exporter reliant on transit routes for its oil. Over 80% of Kazakh oil exports are transported via the Caspian Pipeline Consortium (CPC) pipeline through Russia. This creates a transit dependency risk: geopolitical tensions or infrastructural disruptions can directly curtail export capacity. For example, CPC operations faced interruptions in 2022–2023, raising concerns about Kazakhstan's export security. The uncertainty over continued reliable access to Russian transit routes has prompted Kazakhstan to explore alternative export corridors (such as trans-Caspian routes and Chinese pipelines), but these remain limited in capacity. In addition, broader regional risks – including potential sanctions spillovers or conflicts – further threaten the stability of demand and transit for Kazakhstan's energy exports.

Internal challenges compound these external risks. The FEC's infrastructure is aging and in need of modernization. Many large coal-fired power plants have operated beyond their design life, with an average age of around 55 years, and gas-fired plants average 40 years. As a result, equipment deterioration is a serious issue: by 2024, an estimated 57% of major equipment in power plants was worn out, and the average wear of power grids reached 66%. This leads to high losses (up to 11% of electricity is lost in transmission) and frequent outages. Some older combined heat and power (CHP) plants report critical wear levels of 80–85%, posing risks of accidents and reliability problems. The upstream oil and gas infrastructure also faces constraints – for instance, limited gas processing capacity and periodic maintenance shutdowns curtail output. Thus, insufficient past investment in maintenance and upgrades has created operational risks and inefficiencies. Notably, Kazakhstan's economy is among the top ten most energy-intensive globally, using about three times more energy per unit of GDP than the OECD average. This indicates significant potential for efficiency improvements, which is an area of innovative development (e.g., advanced technologies for energy saving) that can yield both economic and risk reduction benefits.

The Government of Kazakhstan recognizes these challenges. Policy documents like the "Kazakhstan-2050" Strategy and the Low-Carbon Development Strategy (LEDS 2060) emphasize the need for economic diversification and innovative development, including in the energy sector. Ensuring energy security and sustainable growth has become a national priority, especially after recent shocks such as the 2020 oil price crash and the geopolitical shifts of 2022. Innovative development in the FEC implies not only the introduction of new technologies (e.g., digital oilfield management, smart grids, renewable energy technologies) but also innovative approaches to financial and risk management. In this context, effective financial management strategies – prudent budgeting, investment planning, and use of financial buffers – and risk management strategies – identification, assessment, and mitigation of risks – are crucial to bolster the FEC's resilience. By improving

how financial resources are allocated and risks are controlled, Kazakhstan's FEC can better withstand external shocks and internally drive modernization.

However, there is a research gap in understanding how exactly financial and risk management practices in Kazakhstan's FEC should adapt under innovative development. Previous studies have often treated financial stability and innovation separately. This paper aims to bridge that gap by analyzing the sector's recent performance and risk profile, and by evaluating strategies that integrate financial prudence with innovation-led growth. The research goal is to identify and justify strategies of financial management and risk mitigation that ensure the sustainable development of Kazakhstan's fuel-energy sector in an era of innovation. Key questions addressed include: (1) What are the main financial risks and challenges facing the FEC in the past 5–10 years? (2) How can modern risk management tools (such as scenario modeling, diversification, hedging, insurance, etc.) be applied in the sector's context? (3) How do innovative development initiatives (like expanding renewables or introducing new technologies) impact financial performance and risk levels? (4) What strategies can harmonize financial stability with long-term innovative growth?

Kazakhstan and international experience suggests that a synergetic approach is needed – one that simultaneously develops "energy pluralism" (diversification of energy sources) and emphasizes innovative development as part of national policy. In other words, Kazakhstan's energy strategy is moving toward a multi-vector model: continuing to leverage oil and gas while aggressively investing in alternative energy and modern technologies to future-proof the sector. This study contributes by providing an analytical basis for such strategies, grounded in data analysis and scenario evaluation tailored to Kazakhstan's conditions.

Innovation management is increasingly recognized as a strategic priority for the sustainable development of the fuel and energy complex (FEC), especially in regions where energy systems are dominated by traditional fossil fuels (Wang, 2024). Zemlyacheva (2022) highlights that innovation plays a dual role—not only as a source of technological modernization but also as a mechanism to adapt the FEC to external and internal development risks. The author argues that effective innovation management must align with regional economic goals and be institutionalized across all levels of energy governance. Supporting this idea, Zotov (2023) emphasizes the need for sustainable development in petroleum and gas chemical enterprises through qualitative risk assessments and industrial modernization. Likewise, Yin et al. (2024) propose a fuzzy model for financial risk evaluation in the context of new energy vehicles, demonstrating how internal controls and entropy-weighted analysis can enhance financial stability and performance. These studies share a common view: innovation must be strategically managed alongside financial and operational risks to ensure resilience.

Financial risk management models also offer critical tools for integrating uncertainty into long-term energy planning. Ahmed et al. (2014) apply a two-stage stochastic programming framework to assess financial risks in energy projects under

demand and fuel price uncertainty, highlighting the value of scenario-based planning for future investments. Apak et al. (2011), in their comparative analysis between the EU and Turkey, show that financial risk in renewable energy can be mitigated through regulatory stability, investment incentives, and cost-effective technology deployment. In a broader policy context, Zholamanova et al. (2023) compare EU strategies for innovative energy development, emphasizing coordination between national goals and technological modernization. From a regional planning perspective, Khasaev and Tsybatov (2017) underline the importance of simulation tools and strategic modeling to achieve energy efficiency and minimize losses. Together, these works build a conceptual foundation for understanding how financial, operational, and innovation strategies can converge to transform the FEC into a more adaptive and sustainable sector.

Materials and Methods. This research employs a combination of qualitative and quantitative methods. First, a comprehensive literature review was conducted, covering academic journals, policy papers, and industry reports on Kazakhstan's energy sector, financial management in energy companies, and risk management frameworks. Sources included works by local researchers and institutions, such as the Economic Research Institute and Eurasian Research Institute, as well as international sources (World Bank, IMF, IEA, etc.). This review established the theoretical baseline and identified documented challenges and proposed solutions. For instance, prior analyses highlighted Kazakhstan's vulnerability to oil price cycles and the necessity of economic diversification. Comparative insights were drawn from the experience of other energy-exporting countries in managing volatility – e.g., the use of oil funds in Norway and Azerbaijan, and hedging programs in Mexico – to inform potential strategies for Kazakhstan.

Second, the study collected and analyzed empirical data from the last five years (2019–2023) to capture recent trends. Key indicators included oil and gas production volumes, export revenues, world oil prices, the share of fuel sector in GDP and exports, capital investment levels, and renewable energy capacity growth. Statistical data were sourced from Kazakhstan's Ministry of Energy, Ministry of National Economy, the National Bank, and international databases (OPEC, BP, IEA).

Furthermore, risk mapping techniques were applied. We identified major categories of risk – market risk (price volatility), operational risk (outages, accidents), project risk (cost overruns, delays), regulatory risk (policy changes), and transit risk (export route disruption) (Ige et al., 2024). Using expert input from literature and industry reports, we estimated each risk's likelihood and impact on the FEC. For example, the risk map highlighted market price volatility and transit bottlenecks as high-impact, and currency/exchange risks (as much sector financing is in foreign currency) as a notable factor raising the cost of capital. We also examined risk mitigation measures currently in place or proposed: e.g., Kazakhstan's use of long-term oil contracts, the presence (or absence) of hedging programs for oil exports, insurance for infrastructure, and diversification efforts (like investments in petrochemicals, which add value and hedge against crude price swings).

The methods were underpinned by an integrated analytical framework. We combined elements of financial analysis (ratios, trends), economics (scenario modeling, multiplier effects), and strategic management (SWOT analysis for the FEC under innovation). This interdisciplinary approach ensured that the proposed strategies are financially sound, economically feasible, and strategically aligned with Kazakhstan's innovation ambitions. All data analyses were performed using tools like Excel and statistical software for consistency checks and sensitivity analysis. Where data was uncertain (e.g., future oil demand scenarios or technology costs), ranges were used to reflect uncertainty.

The study's reliability is strengthened by sourcing data from reputable publications and by cross-verifying information. For example, to confirm the share of renewables and coal in the power mix, data from national sources were cross-checked with International Energy Agency figures (which indicate electricity generation was ~65% coal, 26% gas, 8% large hydro, ~1–3% other renewables in recent years). Such triangulation lends credibility to the findings. Limitations of the methodology include the unpredictability of certain factors (geopolitical events, global recessions) that scenarios can only partly capture, and the assumption that past data trends can inform future outcomes (which may not hold if there are structural breaks). Nonetheless, the methodological combination of literature review, data analysis, and scenario planning provides a robust basis to derive insights and recommendations.

Results and Discussion. The analysis confirms that Kazakhstan's FEC remains dominated by fossil fuels in output and revenue structure, but early signs of diversification are emerging. Oil production hovered around 85–90 million tons per year, making Kazakhstan one of the world's top 10 oil producers. Natural gas production has likewise grown modestly (reaching ~59 billion m^3 in 2024). These levels allowed Kazakhstan in early 2025 to achieve a record oil output of 2.03 million barrels per day. Export-wise, crude oil continues to be the flagship commodity – with Europe and China as major markets – followed by natural gas and uranium. This high concentration on raw exports is reflected in trade stats: in 2023, fuels comprised 59% of goods exports and metals another ~15%, meaning roughly three-quarters of export earnings came from extractive industries. Such concentration indicates a persistent diversification deficit in the economy.

This reliance on fossil fuels is also evident in Kazakhstan's primary energy consumption structure over the past decade. Despite national strategies to diversify the energy mix and reduce dependence on hydrocarbons, coal, oil, and natural gas continue to dominate. However, small but steady growth in solar and wind energy indicates progress toward energy diversification. The figure below shows Kazakhstan's primary energy use by source from 2015 to 2024 (in thousand toe).

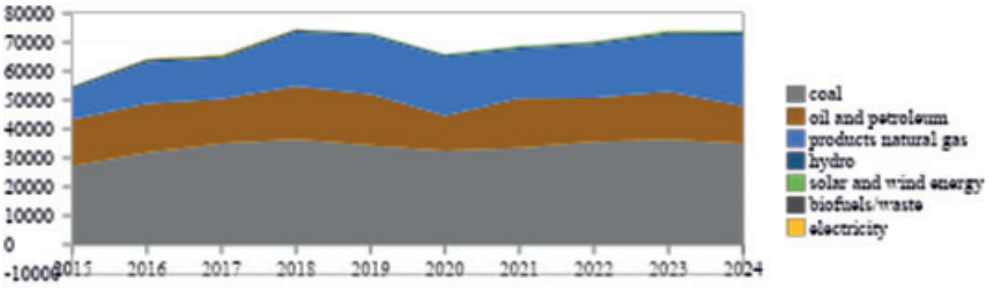

Figure 1 – Dynamics of primary energy consumption in Kazakhstan by energy source, 2015–2024 (thousand toe)

From 2015 to 2024, coal remained the largest energy source in Kazakhstan's fuel mix, growing from 27,343.6 ktoe to a peak of 36,454.0 ktoe in 2023, before slightly declining in 2024. Oil and petroleum products exhibited fluctuating trends, with notable declines in 2020 and 2024 due to external shocks and domestic production adjustments. Natural gas use steadily increased, rising from 10,607.3 ktoe in 2015 to 24,564.3 ktoe in 2024—more than doubling, largely driven by industrial demand and domestic energy substitution policies.

Financially, the FEC's performance is closely tied to global commodity cycles. Government data show that in the oil price crash year of 2020, Kazakhstan's oil GDP (the portion of GDP from oil & gas) shrank (real oil sector output –1.7%), dragging overall GDP to a 2.6% contraction. The budget went into deficit as oil revenue fell to about 5.7% of GDP in 2020–2021. Conversely, the 2022 price boom led to windfall gains: export revenues jumped, and real oil sector growth was +7% that year. However, despite high prices, Kazakhstan still faced fiscal strains – the budget deficit reached ~3% of GDP in 2022–2023. One factor was the legacy contracts with foreign oil majors, which entitle them to a large share of profits from Kazakhstan's biggest fields. Some 60–70% of hydrocarbon output comes from three giant projects (Tengiz, Karachaganak, Kashagan) developed under 1990s production-sharing agreements. Under those terms, foreign investors initially recoup costs and take the lion's share of revenue; as a result, it's estimated that up to 95–98% of the revenue from certain fields currently goes to the companies, not the state. This imbalance has limited the government's take even during boom times and prompted a recent push to renegotiate contract terms.

In terms of risk factors, the results highlight several critical ones:

The volatility of oil and gas prices remains the foremost risk to the FEC's financial stability. The scenario analysis showed that in a low-price scenario (e.g., oil ~$40), Kazakhstan's annual export income could drop by over 40% compared to baseline, leading to a drastic reduction in fiscal revenues (since about half of government revenue can come from oil in good years). This would widen the budget deficit and deplete fiscal buffers. For instance, under a price drop scenario in our model, the National Fund's transfers would need to increase, potentially cutting its assets by nearly 44% over a few years. Conversely, a high-price scenario (oil ~$100)

would roughly double export earnings and could lead to a fiscal surplus, but it also tends to appreciate the real exchange rate (making non-oil sectors less competitive) – a phenomenon known as Dutch disease. Thus both extremes pose management challenges. The financial risk here is the boom-bust cycle affecting budget planning and investment. Notably, Kazakhstan's tax system amplifies this: a large portion of oil revenues comes from export duties and rent taxes that fluctuate with price. The result is pro-cyclical public finances (e.g., in 2022, extra oil income led to increased spending, while 2023's lower price created a shortfall). The IMF has warned that Kazakhstan needs to avoid pro-cyclical fiscal patterns and strengthen its non-oil revenue base.

As mentioned, over four-fifths of oil exports go through CPC and Russian territory. In 2022, this route faced temporary closures (officially due to storm damage at terminals, though geopolitical tensions were suspected to contribute). Each closure or capacity constraint directly translates to output shut-ins or the need for costly rerouting (e.g., via rail or smaller pipelines). Our scenario analysis included a "transit shock" where the CPC capacity is cut by 50% for six months – the result was a potential ~20% reduction in annual oil export volume and billions in lost revenues. The risk is exacerbated by the lack of readily available alternative routes: the trans-Caspian oil export option (swapping or barging to Azerbaijan to access the BTC pipeline) and the China pipeline (Atasu-Alashankou) have far lower capacity than CPC. Thus, any serious or prolonged disruption in northern routes is a strategic risk for Kazakhstan's FEC. Additionally, regional geopolitical risks such as sanctions on pipeline operators or banking restrictions (e.g., sanctions on Russia's Gazprombank in 2022 complicated payments for energy) can indirectly affect Kazakhstan. The ERI analysis noted that an extended conflict or sanctions regime could weaken Kazakhstan's currency (tenge) and elevate inflation, indirectly straining energy companies' finances through higher import costs and credit risks.

The results show that operational reliability is a growing concern. Aging equipment, as noted, leads to frequent breakdowns and maintenance downtime. In the power sector, Kazakhstan experienced record electricity consumption in recent winters, leading to supply deficits and emergency imports from Russia. In 2021 and 2022, several accidents in coal power plants caused nationwide power outages. Similarly, in oil & gas, unplanned outages occurred at Kashagan in 2022 (a gas leak forced a months-long shutdown) and at Tengiz during COVID-19 (when an outbreak among workers slowed expansion works). These incidents underline operational risk, often linked to inadequate maintenance or delayed upgrades. The financial impact is seen in lost production and revenue, as well as increased costs for emergency fixes. Another facet is environmental and safety risk: older infrastructure heightens the chance of industrial accidents (e.g., oil spills, mine accidents), which could incur heavy liabilities or force project suspensions. The analysis of corporate reports indicates that major companies like KazMunayGas (KMG) have started to increase capital expenditures for modernization in 2021–2023, partly to address these risks, but the investment levels may need to double to significantly reduce the average equipment age in the next decade.

Regulatory uncertainty can also be problematic. For example, domestic energy tariff policy has historically kept electricity and heat prices low via subsidies. While this aids consumers, it has meant that power utility companies had insufficient funds for re-investment, contributing to the infrastructure deterioration. Recently, the government has been enacting tariff reforms (raising electricity tariffs gradually to cost-recovery levels), which is expected to improve the financial sustainability of energy providers. However, abrupt changes or lack of clear long-term policy can deter investment. Also, Kazakhstan's renewable energy support scheme (feed-in tariffs and auctions) carries some policy risk if contracts are not honored or if rules change unpredictably. The UNDP's analysis of renewable energy investment in Kazakhstan identified "power market risk" – essentially regulatory risk around tariffs and off-taker agreements – as a top barrier raising the cost of capital for renewables. Thus, transparent and stable regulations are essential for lowering risk premiums.

On a positive note, the results highlight progress in innovative development that can mitigate some risks. Kazakhstan has significantly expanded its renewable energy capacity in the last five years. From a very low base of about 1–2% of generation in 2018, renewables (solar, wind, small hydro) grew to 3% of total electricity by 2021 and roughly 5–6% by 2023. By end of 2024, renewables accounted for 6.4% of generation, exceeding interim targets. Including large hydropower (~8%), total low-carbon sources now make up about 14% of electricity output. This trend, aided by government auctions and foreign investment, indicates diversification of the energy mix. The financial implication is that over time, the power sector will rely less on imported coal and gas and more on domestic renewables, which have zero fuel cost and lower marginal cost volatility. Already, 154 renewable energy facilities (3 GW capacity) are operational, and auctions for an additional 6.7 GW by 2027 have been announced. Our optimistic scenario projects Kazakhstan could achieve 10–12% non-hydro renewables by 2030, approaching the official goal of 15%, if current momentum continues. This reduces long-term carbon transition risk (important as trading partners enact carbon tariffs) and creates new industries (wind, solar manufacturing) that broaden the economic base.

Another noteworthy result is improvement in institutional financial mechanisms. Kazakhstan's National Fund, modeled as a stabilization and savings fund, has been actively used to cushion budget fluctuations. As of end 2023, the National Fund held about 23% of GDP in assets. In 2020–2022, large drawdowns from the fund were made to finance stimulus and offset revenue loss. While the fund's balance declined, this counter-cyclical use helped avoid deeper cuts to public investment. The risk is over-reliance: in 2023–2024 transfers reached record levels (over 6 trillion ₸), prompting warnings that continued high withdrawals could deplete the fund for future generations. Nevertheless, the existence of the fund remains a key risk management tool at the national financial level. Similarly, Kazakhstan's public debt (about 23% of GDP in 2024) is relatively low, giving the government borrowing capacity if needed for critical investments. Officials have framed the recent rise in debt as an investment in development, noting it is being channeled to infrastructure

and that debt levels are still moderate. This perspective, while debatable, suggests fiscal space is available to fund innovative projects (e.g., renewable infrastructure, digitalization of grids) that can enhance long-term resilience.

In summary, the results paint a picture of an energy sector at a crossroads: highly exposed to traditional risks (price swings, aging assets, transit chokepoints) yet gradually adopting innovations (renewables, efficiency measures, financial buffers) that could alleviate those risks. Quantitatively, our scenario modeling indicates that by implementing a set of risk management strategies (described in the next section), Kazakhstan can significantly improve key outcomes. For instance, in a stress scenario of low oil prices, without any policy response the budget deficit could have widened to over 5% of GDP; with prudent financial management (e.g., spending cuts, using the National Fund judiciously) and increased non-oil revenues, the deficit might be contained below 3% of GDP, avoiding a fiscal crisis. Likewise, diversifying the energy mix is projected to reduce the standard deviation of Kazakhstan's energy export revenues (a proxy for volatility) by 10–15% by 2030, as earnings from renewables and electricity exports start to offset some oil revenue fluctuations. These quantitative outcomes highlight the tangible benefits of combined financial and innovative strategies.

In addition to the structural analysis of primary energy sources, it is essential to examine how energy consumption is distributed across Kazakhstan's economic sectors. The country's fuel and energy complex (FEC) remains highly centralized, with the industrial and transport sectors historically accounting for the largest shares. However, recent trends reveal important shifts. Notably, household energy consumption has steadily increased, while the industrial sector's share has declined due to structural adjustments, energy-saving measures, and reduced industrial output in certain years. The chart below illustrates the dynamics of energy consumption by sector from 2015 to 2024, both in absolute values (thousand toe) and as a percentage of total consumption.

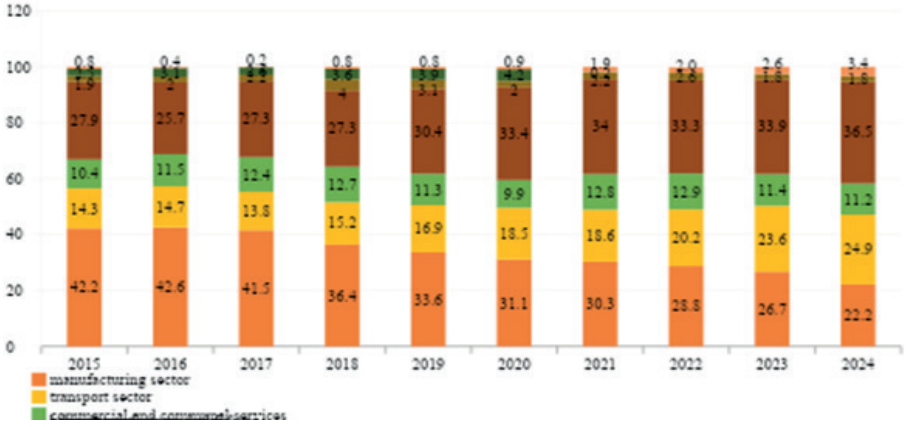

Figure 2 – Energy consumption by economic sector in Kazakhstan, 2015–2024 (thousand toe and % share)

As shown in the figure, energy consumption by the industrial sector decreased significantly—from 16,178 ktoe in 2015 to just 9,898.6 ktoe in 2024—while its share in the total energy balance fell from 42.2% to 22.2%. In contrast, the transport sector's energy use rose steadily, surpassing 11,000 ktoe by 2024 and increasing its share from 14.3% to 24.9%. The housing sector (population) became the second-largest consumer, growing from 10,711 ktoe in 2015 to over 16,300 ktoe in 2024, with its share rising to 36.5%. This reflects growing urbanization, rising living standards, and increased energy demand in residential areas. The commercial and utility sector showed moderate fluctuations, while agriculture remained a minor consumer. A notable trend is the increase in non-energy use—such as feedstock for petrochemicals—which rose from 302.7 ktoe to 1,523.6 ktoe over the period.

The findings of this study align with and extend the insights of other researchers and policymakers, reinforcing the view that an integrated approach to managing risks and finances in the fuel-energy sector is necessary for Kazakhstan's sustainable development. Comparatively, Zhanbulatova et al. (2021) described Kazakhstan's strategy of "energy pluralism" – essentially pursuing a mix of energy sources – as a synergetic policy response to development risks in the FEC. Our results support this approach: diversification across energy sources (oil, gas, renewables, potential nuclear and hydrogen in future) can indeed spread and reduce risk. For example, hydropower and wind can hedge partly against fuel supply disruptions and provide cost stability. By emphasizing innovative development (e.g., local renewable technology, energy storage, smart grids), Kazakhstan is not only addressing environmental goals but also building a more resilient energy system less prone to single-point failures. This echoes global trends where energy transition is seen as a strategy for risk mitigation (climate risk, price risk) as much as an environmental necessity.

However, implementing these strategies requires overcoming certain institutional and market barriers. One major challenge is attracting sufficient investment into new energy projects and infrastructure upgrades. The Kazakh government has signaled strong support for this: establishing feed-in tariffs, green auctions, and improving the tariff regulation for utilities. Additionally, policy measures like the recent capacity market for power and planned introduction of a market-based tariff setting are expected to improve the bankability of energy projects. These efforts are crucial because historically, low tariffs and perceived high risk deterred private investment (leading to situations like underinvestment in the power sector and the 5.3 bln USD/year fossil fuel subsidies in 2014 that UNDP noted). Now, with better tariff incentives and risk reductions (e.g., government-backed power purchase agreements), investor interest is rising. For example, several foreign companies (from EU, China, UAE) have invested in Kazakh wind and solar farms in the past three years, something that was rare a decade ago.

A point of discussion is the role of the National Fund and fiscal policy in risk management. The National Fund has served as a stabilization buffer, but heavy reliance on it could undermine long-term fiscal health. There is debate among economists in Kazakhstan on the optimal use of the Fund. Some argue it should

strictly save oil windfalls for future generations, while others support its use for development projects now (the "debt as investment" view). Our findings suggest a balanced approach: using the Fund counter-cyclically to smooth out downturns is wise (as was done in 2020–21), but structural deficits should be addressed through budget reform rather than continuous Fund withdrawals. The IMF's 2025 Article IV consultation also warned about continued reliance on discretionary National Fund transfers, recommending a more rules-based fiscal framework and improved non-oil revenue mobilization. In practice, Kazakhstan is moving to tighten fiscal rules (planning to cap how much can be taken from the Fund annually). A stable fiscal environment will, in turn, give confidence to investors and credit rating agencies, lowering the cost of capital for FEC projects. It is noteworthy that Kazakhstan's public debt remains relatively low, which is a financial strength – it means the government can borrow (ideally on domestic markets, as planned) to finance critical energy infrastructure without threatening debt sustainability. Ensuring those borrowed funds are used efficiently for diversification projects is crucial.

Another aspect is enterprise-level risk management. International best practices (e.g., COSO ERM framework, ISO 31000) are gradually being adopted by large Kazakh energy companies, but there is room for improvement. KazMunayGas, for instance, has started producing detailed risk reports, mapping out market, operational, and ESG (environmental, social, governance) risks in its annual report. They have also initiated hedging on a small portion of crude output and use insurance for some projects. However, these practices are not yet industry-wide. Smaller companies and state operators in coal/power may lack advanced risk management units. There is an opportunity to establish standard requirements or incentives for financial risk management in energy firms – for example, training in derivative use for price hedging, creating consortia for mutual insurance of critical infrastructure, or mandating risk audits. The government, as a major shareholder in many FEC enterprises via sovereign wealth holdings, can push for improved corporate governance and risk oversight. This was one recommendation from our results: strengthen corporate governance mechanisms. Essentially, better governance will facilitate innovative projects (as investors will trust companies with sound management) and control risks (through transparency and accountability).

The discussion of results against other scholars shows both agreement and some new contributions. Previous analyses (e.g., by Khitakhunov (2024) at ERI) primarily identified problems – high dependence on oil, transit vulnerabilities, etc.– and broadly called for diversification and renewables. Our study not only reiterates those but also quantifies the potential impacts of specific measures. For instance, by mapping an optimistic scenario, we concretely show that achieving the 15% renewables target by 2030 could reduce Kazakhstan's vulnerability to oil price busts (by preserving export revenues from alternative sources and reducing domestic consumption of exportable fuels). We also highlight the importance of energy efficiency – something sometimes overshadowed by talk of renewables. Kazakhstan's energy intensity (three times OECD average) means huge gains are possible via modernizing technology

and reducing wastage. The IMF 2025 report likewise stresses accelerating fossil fuel subsidy reform and enhancing energy efficiency as part of a comprehensive response to climate and competitiveness challenges. Energy efficiency investments (insulation, CHP upgrades, industrial retrofits) often have high payback and directly cut operational risk (less stress on the grid, for example). Therefore, one discussion point is that innovative development is not just about adding new generation (like wind farms), but also about smarter consumption and distribution. Digital technologies (smart meters, AI for grid management) can reduce losses and balance load, as evidenced by pilot projects in Kazakhstan that cut distribution losses and improved reliability in some regions.

It is also insightful to compare Kazakhstan's approach with other oil-producing countries. Kazakhstan has some similarities with countries like Russia and Azerbaijan (high hydrocarbon share, oil funds) and differences with, say, Gulf states (which have more oil but also more financial firepower). Azerbaijan's experience with its Oil Fund and attempts at diversification show that political will and governance are key – excess spending and corruption can derail the best strategies. Kazakhstan has made improvements in public financial management, but issues remain (e.g., ensuring transparency in how extra oil revenues are used, avoiding white-elephant investments). The anti-corruption and governance reforms ongoing since 2019 are part of improving the investment climate and effective risk management, as corruption itself was a risk (it could lead to inefficient contracts, safety shortcuts, etc.). The Carnegie analysis by Kospanov (2025) highlights how Kazakh authorities are now re-examining old contracts partly to correct imbalances possibly caused by corruption or weak negotiation in the 1990s. This indicates a learning process: early exploitation of resources came with costly concessions; now, with a stronger state and new generation of officials, Kazakhstan is asserting more control. Renegotiating contracts (within legal bounds) and pursuing compensation for cost overruns (as with the Kashagan $13 billion claim in 2023) are bold steps that could improve the state's financial position and set precedents for fairer risk-sharing with foreign investors. Of course, this must be balanced against not discouraging future investment; maintaining a stable business environment is important. The discussion here is that financial management at the sector level sometimes means renegotiating terms and improving state equity in lucrative projects, which is a form of portfolio risk management (ensuring the state isn't bearing all risks for little reward).

Finally, the results underscore the synergy between innovation and risk management. Innovative development in the FEC – such as introducing renewables, energy storage, digital monitoring, and even exploring hydrogen fuel – is often viewed through the lens of modernization and climate commitments. But our analysis shows it should equally be seen as a risk mitigation strategy. By reducing over-reliance on any single energy resource or route, innovation inherently spreads risk. For example, if Kazakhstan develops green hydrogen in the future, that could open a new export revenue that does not correlate with oil price fluctuations, thereby stabilizing income. The low-carbon transition, often deemed a risk to oil-dependent

economies, can also be an opportunity to hedge against the decline of fossil fuels. In this light, Kazakhstan's updated NDC and carbon neutrality pledge by 2060 can be interpreted not just as environmental altruism but as a long-term risk management framework. The IEA's analysis of Kazakhstan recommends modernizing energy infrastructure and phasing out fossil subsidies urgently, to meet climate goals and ensure resilience– essentially tying together risk reduction (less waste, less emissions risk) with innovation (new tech, clean energy) (Akhigbe et al., 2024). The discussion concurs that Kazakhstan should press ahead with these reforms. The trade-offs (like short-term cost of transition, potential social impacts of higher tariffs) need to be managed through careful policy (e.g., targeted support for vulnerable groups alongside tariff hikes).

In conclusion, comparing our results with existing opinions reveals broad agreement that diversification, sound financial management, and innovation are the pillars for reducing Kazakhstan's FEC risks. Our contribution provides a more detailed roadmap and quantification for these pillars. Potential weaknesses or criticisms of our approach may include the uncertainty of scenarios (e.g., one could argue we assume renewables will indeed be integrated smoothly, which depends on grid upgrades and storage – an area Kazakhstan must invest in). Additionally, some might point out that as long as oil and gas remain profitable, there will be political temptation to delay diversification (the so-called resource curse of complacency in boom times). This is a valid concern: e.g., after the 2000s oil boom, diversification initiatives slowed. The current government appears aware of this, hence the insistence on innovation even when oil prices are decent. Ensuring consistent policy commitment is key – a matter beyond pure economic analysis, touching on governance and public administration.

Future research could build on this work by conducting stress tests at the company level (how would KMG or KEGOC fare under various shocks) or evaluating social implications (how to retrain workforce from fossil industries to new sectors, as part of just transition). But from a macro and sectoral perspective, this discussion affirms that Kazakhstan's path forward lies in managing what it cannot control (global markets) by fortifying what it can control (financial buffers, domestic reforms, and innovation). The results and comparisons demonstrate that with prudent strategies, Kazakhstan can turn its fuel-energy complex from a source of vulnerability into a foundation for stable and innovative growth.

Conclusion. In summary, the research findings lead to several key conclusions regarding financial and risk management strategies for Kazakhstan's fuel and energy complex under conditions of innovative development:

1. Reducing over-reliance on oil and gas is critical for mitigating risk. This includes diversifying the energy mix (greater development of renewable energy, hydro, and potentially nuclear) and diversifying export routes and markets. A more balanced energy portfolio will lower vulnerability to commodity price swings and transit disruptions, enhancing energy security. In practice, this means sustained support for renewables (to reach the 15% by 2030 target and beyond) and investment in alternative export infrastructure (e.g. Caspian routes, LNG or value-added products) should be strategic priorities.

2. Effective financial management requires maintaining and prudently using stabilization mechanisms like the National Fund and keeping public debt at sustainable levels. The government should continue to refine fiscal rules to avoid pro-cyclical spending – saving more in boom times and drawing down in lean times, within limits. This smoothing will protect critical investments in innovation even during downturns. Additionally, improving non-oil revenue (tax reforms, widening the tax base) will reduce the budget's sensitivity to oil price shocks. By enhancing fiscal discipline and transparency (e.g., limiting off-budget expenditures and discretionary fund transfers), Kazakhstan can ensure that it has the financial resilience to support long-term innovative projects irrespective of external volatility.

3. Both at the national and corporate level, adopting systematic risk management is necessary. This includes scenario planning (as used in this study) to inform decision-making, the use of hedging instruments to manage price risk for oil exports, adequate insurance coverage for infrastructure, and regular stress-testing of key energy companies and projects for various risk factors. The creation of integrated risk management units within major energy companies and better corporate governance will help identify and respond to risks early . For example, the government and KMG could explore hedging a portion of oil output to secure minimum price levels, and power companies should plan for contingency fuel supplies and reserve margins to handle extreme peaks or outages. Adopting international standards (ISO 31000) and seeking independent audits of risk management systems can further professionalize this aspect.

4. Invest in Innovation and Infrastructure Modernization: Innovative development should be leveraged as a risk mitigation tool. Investments in upgrading aging infrastructure (power plants, grids, pipelines) will reduce operational failures and energy losses, directly addressing one of the sector's prominent internal risks. Furthermore, embracing new technologies – such as smart grid management, digital monitoring of pipeline integrity, and advanced drilling and recovery techniques – can improve efficiency and reduce costs, strengthening financial performance. The government's focus on cleaner energy (e.g., distributed solar, energy storage pilot projects) and energy efficiency programs should continue, as they not only pursue climate goals but also improve the robustness of the energy supply. In essence, modernization efforts (many of which qualify as innovative developments) are investments into the long-term stability and productivity of the FEC. These efforts will require significant capital; thus, public-private partnerships and attracting foreign direct investment into these projects will be important, supported by the improved financial and regulatory environment.

Overall, the integration of sound financial management with proactive risk mitigation and innovative growth forms the cornerstone of a sustainable strategy for Kazakhstan's fuel and energy complex. By following the outlined strategies – diversifying energy sources and revenues, maintaining financial safeguards, institutionalizing risk management, and modernizing infrastructure through innovation – Kazakhstan can enhance its energy security and economic resilience. These measures will enable the FEC to continue as a driving force in the national

economy, while progressively reducing its exposure to external shocks and paving the way for a transition to a more diversified, technologically advanced energy sector. The practical implication is that policymakers and industry leaders should treat innovation not as a separate agenda but as an integral part of risk management, and vice versa, thereby ensuring that the sector's evolution in coming decades is both sustainable and secure.

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