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THE IMPACT ANALYSIS OF VARIOUS BUDGET MANAGEMENT SYSTEMS IN ESTABLISHING SUSTAINABLE HYDROGEN SUPPLY CHAIN IN CENTRAL ASIA

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Abstract
The emergence of hydrogen as a key element in the global green transition has sparked interest in developing sustainable hydrogen supply chains, especially in regions with high renewable energy potential such as Central Asia. However, the realization of this potential is closely tied to how public resources are managed and allocated. This study investigates the role of different budget management systems—namely traditional, program-based, and performance-based budgeting—in facilitating the establishment of a sustainable hydrogen supply chain in Central Asia. The analysis focuses on how these systems influence investment planning, inter-sectoral coordination, financial transparency, and long-term policy implementation. Through a comparative evaluation of budgetary practices in Kazakhstan, Uzbekistan, and Turkmenistan, the study identifies critical enablers and bottlenecks within each system. The findings underscore that transitioning to modern, performance-oriented budgeting models is essential to attract investment, ensure accountability, and support green infrastructure development, ultimately accelerating the region's transition to a hydrogen-driven energy future.

Keywords: Hydrogen supply chain, budget management systems, sustainable energy, performance-based budgeting, program-based budgeting, Central Asia, green hydrogen, public finance, renewable energy investment, fiscal policy

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Introduction

As the global energy landscape undergoes a fundamental transformation, green hydrogen has emerged as a promising solution for achieving decarbonization goals and ensuring long-term energy security. Owing to its versatility, hydrogen can be produced using renewable energy sources and utilized across multiple sectors, including transportation, industry, and power generation. Central Asia, with its abundant solar and wind resources, strategic geographic location, and growing interest in clean energy, is well-positioned to become a regional hub for hydrogen production and export.

However, the successful establishment of a sustainable hydrogen supply chain requires more than natural resource potential—it demands a robust governance and financing framework. In particular, public sector budgeting systems play a crucial role in determining how effectively governments can allocate resources, incentivize investment, and implement strategic energy initiatives. The capacity of a country to finance green infrastructure, manage long-term risks, and coordinate cross-sectoral activities depends significantly on the efficiency, flexibility, and transparency of its budget management system.

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In this context, the present study investigates the influence of various budget management systems—traditional, program-based, and performance-based—on the development of hydrogen supply chains in Central Asia. The research focuses on three countries with differing levels of budget reform and energy policy maturity: Kazakhstan, Uzbekistan, and Turkmenistan. By analyzing how each system affects the mobilization and governance of financial resources, the study aims to identify which budgeting approaches are most conducive to building a resilient, scalable, and sustainable hydrogen ecosystem in the region.

Literature Review

The interrelation between public financial management and the development of sustainable energy systems has been widely explored in recent years. Scholars agree that effective budgeting frameworks are essential for the strategic allocation of public funds, particularly in infrastructure-heavy sectors such as renewable energy and hydrogen (OECD, 2021; World Bank, 2022)[1].

Hydrogen is increasingly recognized as a cornerstone of the global green transition, with its potential to decarbonize hard-to-abate sectors. According to the International Renewable Energy Agency (IRENA, 2023)[2], investment in hydrogen infrastructure must be guided by coherent national strategies and supported by transparent public financing mechanisms. Various studies emphasize that without efficient government intervention and financial planning, the hydrogen economy cannot achieve scale or competitiveness, especially in developing regions like Central Asia (IEA, 2022; BNEF, 2021).

Budget Management Systems and Sustainable Development Budgeting systems influence not only how resources are allocated but also how performance and accountability are ensured. Traditional (line-item) budgeting systems have been criticized for their lack of flexibility and results orientation (Allen & Tommasi, 2001)[3]. In contrast, program-based budgeting enables linkage between expenditures and outcomes, thereby aligning fiscal resources with development priorities (Shah, 2007). Performance-based budgeting, as noted by Diamond (2013)[4], further enhances this alignment by incorporating measurable performance indicators and accountability mechanisms into the budget cycle.

Studies conducted in emerging economies show that program and performance-based systems are better suited for managing large-scale, multi-sectoral projects such as hydrogen development. These systems promote fiscal discipline while enabling governments to pursue long-term policy goals, such as decarbonization and energy security (UNDP, 2022; IMF, 2021)[5].

In the Central Asian context, recent reforms in Uzbekistan and Kazakhstan show a trend toward more modern budgeting practices. Uzbekistan has implemented program budgeting in selected

[1] World Bank. (2022). Greening Public Financial Management: A Framework for Climate-Informed Public Budgets. Washington, D.C.: World Bank Group.

[2] International Renewable Energy Agency (IRENA). (2023). Global Hydrogen Trade to Meet the 1.5°C Climate Goal: Green Hydrogen Supply. Abu Dhabi: IRENA.

[3] Allen, R., & Tommasi, D. (2001). Managing public expenditure: A reference book for transition countries. OECD Publishing.

[4] Diamond, J. (2013). Good practice in performance-based budgeting. International Monetary Fund. https://doi.org/10.5089/9781475531091.006

[5] International Monetary Fund (IMF). (2021). Public Financial Management and Climate Change: A Review of Tools and Practices. Washington, D.C.: IMF.

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sectors, while Kazakhstan has initiated a gradual transition toward performance-based budgeting to improve transparency and public sector efficiency (Ministry of Finance of Kazakhstan, 2023)[6]. However, Turkmenistan and other states still rely heavily on traditional budgeting, which limits the capacity for strategic project financing.

Despite increasing recognition of the importance of green budgeting, there is limited research directly linking budget management systems with the development of hydrogen supply chains in Central Asia[7]. This study aims to fill that gap by providing a comparative analysis of how various budgeting approaches influence the financing and governance of hydrogen projects in the region.

Methodology

This study employs a qualitative, comparative research methodology to analyze the impact of various budget management systems on the development of a sustainable hydrogen supply chain in Central Asia. The methodology is designed to capture the relationship between public financial governance practices and strategic energy infrastructure outcomes, focusing on three case countries: Kazakhstan, Uzbekistan, and Turkmenistan.

The research is structured as a multiple case study, allowing for the comparative analysis of different budgeting systems within varied national contexts. Each case represents a distinct approach to public budgeting—Kazakhstan (performance-based), Uzbekistan (program-based), and Turkmenistan (traditional line-item budgeting).

3.3 Analytical Framework

The analysis framework incorporates the following key dimensions:

- Budget System Characteristics: Structure, flexibility, performance orientation, transparency
- Energy Financing Capacity: Ability to allocate funds to hydrogen infrastructure and innovation
- Stakeholder Coordination: Integration of public-private partnerships and donor alignment
- Outcome Effectiveness: Observed progress in hydrogen supply chain development and policy implementation

Each country's budgeting system is assessed against these criteria using a qualitative comparative analysis (QCA) method to identify patterns, contrasts, and causal inferences.

Despite these limitations, the methodology provides a structured lens through which to understand how budget governance impacts the sustainability of hydrogen initiatives in Central Asia.

Result and Discussion

The comparative analysis of Kazakhstan, Uzbekistan, and Turkmenistan reveals that the nature and structure of a country's budget management system significantly influence its ability to develop a sustainable hydrogen supply chain. This section presents the key findings of the study, followed by an in-depth discussion of their implications.

[6] Ministry of Finance of the Republic of Kazakhstan. (2023). Public Finance Management Reform Strategy 2023–2027. Nur-Sultan: Government of Kazakhstan.

[7] United Nations Development Programme (UNDP). (2022). Budgeting for Sustainable Development in Central Asia: Regional Trends and Policy Recommendations. New York: UNDP.

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4.1 Key Findings

Kazakhstan – Performance-Based Budgeting (PBB):

Kazakhstan has made notable strides in transitioning to a performance-based budgeting system. This system links budget allocations to measurable outcomes, enabling more strategic financing of long-term energy projects. The country has introduced a national hydrogen strategy supported by fiscal incentives, pilot projects, and inter-ministerial coordination mechanisms. As a result, Kazakhstan has attracted foreign direct investment (FDI) in green hydrogen production and initiated cooperation with the EU and Japan.

Uzbekistan – Program-Based Budgeting (PrBB):

Uzbekistan operates under a program-based budgeting model in selected sectors, including energy. While the transition from traditional budgeting is ongoing, recent reforms have enabled improved alignment between national energy objectives and budget allocations. However, institutional fragmentation and limited experience with outcome-based planning have slowed the implementation of hydrogen projects. Nevertheless, pilot renewable hydrogen projects are underway in partnership with international agencies.

Turkmenistan – Traditional Line-Item Budgeting (TLB):

Turkmenistan still predominantly employs a traditional line-item budgeting approach. This system focuses on inputs rather than outcomes, limiting flexibility and innovation in public spending. Despite the country's significant natural gas reserves and renewable energy potential, the absence of dedicated budgetary programs for hydrogen development has resulted in minimal progress in this area. Most hydrogen-related initiatives remain at the conceptual stage.

4.2 Comparative Discussion

The study demonstrates that **modern budget management systems—particularly performance-based budgeting—facilitate better alignment between fiscal resources and sustainable energy goals**. Key areas of impact include:

- **Strategic Planning and Policy Coherence:** Countries with modern budgeting systems exhibit higher integration between national development plans and sectoral strategies. Kazakhstan's PBB model enables long-term hydrogen policy execution backed by quantifiable performance targets.
- **Investment Mobilization:** Performance and program-based systems provide greater transparency and predictability, which are crucial for attracting public-private partnerships (PPPs) and international financing.
- **Institutional Coordination:** Budgeting systems that link funding with program outcomes foster better coordination among ministries, agencies, and external stakeholders, reducing project duplication and inefficiencies.
- **Flexibility and Responsiveness:** Traditional systems, while simpler to administer, lack adaptability. This hinders the ability of governments to reallocate funds quickly to emerging priorities such as hydrogen infrastructure.

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4.3 Policy Implications

- Governments in Central Asia should accelerate reforms toward **performance- and program-based budgeting**, especially in sectors critical to green transition.
- There is a need for **capacity-building programs** for public officials to implement modern budgeting tools and monitor hydrogen project performance.
- International donors and development banks should consider the quality of a country's budget system as a **criteria for green investment** allocation.

Table 1. Comparative Matrix: Budget Management Systems and Hydrogen Development Capacity in Central Asia[8]

Criteria	Kazakhstan (PBB)	Uzbekistan (PrBB)	Turkmenistan (TLB)
Budgeting System Type	Performance-Based Budgeting	Program-Based Budgeting	Traditional Line-Item Budgeting
Policy Integration	High – Linked to hydrogen strategy	Moderate – Partial integration	Low – No dedicated hydrogen programs
Outcome Orientation	Strong – Targets and indicators defined	Moderate – Sector programs emerging	Weak – Focus on input allocation
Investment Attraction	High – FDI and donor funding mobilized	Moderate – Selective project funding	Low – Limited international interest
Flexibility in Fund Allocation	High – Adaptive to new priorities	Medium – Some flexibility by program	Low – Rigid, annual allocation focused
Interagency Coordination	Strong – Coordinated governance models	Moderate – Fragmentation persists	Weak – Centralized with low coordination
Hydrogen Project Development Stage	Pilot and pre-commercial projects started	Early-stage feasibility assessments	Conceptual – No active projects yet
Overall Readiness for Hydrogen Chain	High	Medium	Low

Table 1 clearly demonstrates the differentiated impact of budget management systems on the development of a sustainable hydrogen supply chain across Central Asian countries. Kazakhstan, which has adopted a performance-based budgeting (PBB) model, shows the highest institutional readiness and practical progress in hydrogen infrastructure development. Its budgeting system ensures policy coherence, flexible funding allocation, and effective monitoring of outcomes, all of which are essential for the dynamic nature of green hydrogen projects. The presence of targeted performance indicators and strong interagency coordination enables Kazakhstan to attract both foreign direct investment and international donor support for hydrogen initiatives.

In contrast, Uzbekistan's program-based budgeting (PrBB) is in a transitional phase. While sector-specific programs for energy are being introduced, full integration with hydrogen strategies remains limited. Nevertheless, the move away from input-based budgeting has already facilitated the initiation of pilot projects and improved donor engagement. Continued reforms and improved institutional capacity will be crucial for accelerating hydrogen deployment in Uzbekistan.

Turkmenistan, which still relies on a traditional line-item budgeting (TLB) system, faces significant challenges. The rigid structure of this system limits responsiveness to emerging strategic priorities such as hydrogen energy. The lack of performance orientation, coupled with centralized decision-making and minimal external engagement, contributes to a very low level

[8] Author created

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of development in this sector. As a result, Turkmenistan remains largely unprepared to capitalize on the green hydrogen opportunity, despite having significant natural resource potential.

Overall, the matrix highlights that modern, results-oriented budget systems (PBB and PrBB) are far better suited to support innovative and capital-intensive projects like green hydrogen supply chains. For Central Asia to become a competitive player in the global hydrogen economy, a shift toward more transparent, flexible, and strategic public financial management is essential.

Conclusion

This study examined how different public budget management systems affect the establishment and development of a sustainable hydrogen supply chain in Central Asia. Through a comparative analysis of Kazakhstan, Uzbekistan, and Turkmenistan, the research reveals that the structure and performance orientation of a country's budgeting system significantly influence its ability to support and implement hydrogen-related strategies.

Kazakhstan, with its performance-based budgeting (PBB), has demonstrated a higher capacity to strategically allocate resources, attract investment, and ensure interagency coordination, resulting in tangible progress in hydrogen infrastructure development. Uzbekistan's program-based budgeting (PrBB) model, while still evolving, provides a moderate level of support for hydrogen initiatives, showing promise with the initiation of pilot projects and donor engagement. In contrast, Turkmenistan's continued reliance on traditional line-item budgeting (TLB) has constrained its ability to respond to the emerging needs of the green hydrogen sector, with minimal project development and institutional readiness.

The findings suggest that modern, transparent, and outcome-oriented budget systems are essential enablers for the green transition, particularly in capital-intensive and innovation-driven sectors such as hydrogen energy. Therefore, for Central Asian countries to unlock the full potential of green hydrogen and meet their sustainable development goals, it is crucial to advance public financial management reforms, strengthen institutional capacities, and align budgetary practices with long-term energy strategies.

In conclusion, the establishment of a sustainable hydrogen supply chain in Central Asia is not solely a technological or environmental challenge—it is equally a governance and fiscal planning issue. By adopting and refining modern budgeting frameworks, these nations can build a solid foundation for clean energy leadership in the region and beyond.

References

1. Asian Development Bank. (2023). Hydrogen in Central Asia: Opportunities and challenges for low-carbon energy transition. ADB Energy Sector Series. https://www.adb.org

2. Bova, E., Ruiz, I., & Toscani, F. (2021). The effectiveness of performance-based budgeting in the public sector. International Monetary Fund Working Paper No. 21/76. https://www.imf.org

3. Ghosh, S., & Gielen, D. (2022). Hydrogen for net-zero: A critical role in global decarbonization. International Renewable Energy Agency (IRENA). https://www.irena.org/publications

4. International Energy Agency. (2021). Hydrogen Projects Database. IEA Hydrogen TCP. https://www.iea.org

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5. Kuzmina, M., & Abdrakhmanova, G. (2022). Budget reform and energy transition in Kazakhstan. Energy Policy, 164, 112904. https://doi.org/10.1016/j.enpol.2022.112904
6. Ministry of Finance of the Republic of Uzbekistan. (2023). Public finance management reform roadmap (2023–2026). https://www.mf.uz
7. OECD. (2020). Budgeting for performance in transition economies: Practices and pathways. OECD Public Governance Review. https://www.oecd.org
8. Sadykova, N., & Umarov, B. (2023). Hydrogen energy development in Uzbekistan: Policy overview and investment opportunities. Central Asian Economic Review, 5(1), 44–58.
9. United Nations Economic Commission for Europe (UNECE). (2022). Pathways to sustainable hydrogen: Innovation and policy support in Central Asia. https://unece.org
10. World Bank. (2023). Public expenditure review: Uzbekistan. Report No. 180023-UZB. https://www.worldbank.org

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