International Journal of Research Studies on Environment, Earth, and Allied Sciences (IJRSEAS)
| Volume-2 Issue-4 |August-2025 | ISSN: 3066-0637 | Website: https://eesrd.us

Manuscript ID:
IJRSEAS-2025-020404

OPEN ACCESS

Quick Response Code:

Website: https://eesrd.us

DOI: 10.5281/zenodo.17590177

DOI Link:
https://doi.org/10.5281/zenodo.17590177

Volume: 2

Issue: 4

Pp. 14-17

Month: August

Year: 2025

E-ISSN: 3066-0637

Submitted: 06 July 2025

Revised: 10 July 2025

Accepted: 10 Aug. 2025

Published: 31 Aug. 2025

Address for correspondence:
Rakesh Kumar
Assistant Professor, Dept. of Geography, Murarka College, Sultanganj TMBU, Bhagalpur
Email: rkrakrak05@gmail.com

How to cite this article:
Kumar, R. (2025). Renewable Energy Future: Can Large-Scale Solar and Wind Energy Projects in Kazakhstan and Uzbekistan Reduce Dependence on Fossil Fuels and Alter the Region's Energy Geography?. International Journal of Research Studies on Environment, Earth, and Allied Sciences, 2(4), 14–17.
https://doi.org/10.5281/zenodo.17590177

Renewable Energy Future: Can Large-Scale Solar and Wind Energy Projects in Kazakhstan and Uzbekistan Reduce Dependence on Fossil Fuels and Alter the Region's Energy Geography?

Rakesh Kumar
Assistant Professor, Dept. of Geography, Murarka College, Sultanganj TMBU, Bhagalpur

Abstract

Historically, the economies of Central Asia, particularly those of Kazakhstan and Uzbekistan, have exhibited a large dependence upon fossil fuels, so that Kazakhstan generates more than 50% of its energy from coal and Uzbekistan from natural gas almost 80%. These states are now pursuing large-scale investments in extensive solar and wind energy programs. Their strategic shift can be seen as an effort to diversify their energy portfolios, meet climate change obligations, and enhance energy security through measures aimed at implementing global decarbonization. The present paper will investigate whether these proposed measures are capable of significantly reducing fossil fuel dependence and thus transforming the geographical energy relationship, primarily through new infrastructure and cross-border energy transmissions. In the recent past figures reveal that renewable energy sources in Kazakhstan make up 6.8% of electricity generation in early 2025, while Uzbekistan has declared an ambitious target of 40% by 2030. Evidence of strides forward can be seen in the cases such as the Mirny windfarm in Kazakhstan and the Voltalia hybrid plant in Uzbekistan that are expected bring about reductions in emissions with the possibility of green energy exports passing through the Caspian corridors. There remain, however, considerable obstacles to be overcome, such as limitations on grid infrastructure with the persistence of fossil fuel subsidies, financial matters, and political inertia. Scepticism exists among opponents as to the speed and extent of these transitions. It is suggested that those obstructions may limit the anticipated reduction of fossil fuel dependence and the transformation of the geographical energy relationship in the short to medium term. Notwithstanding these drawbacks, the findings tend in the direction of a partial reduction in fossil fuel dependence by 2030, thus creating some notable geographical changes toward emerging renewable energy hubs and enhancing regional integration further.

Keywords*: Kazakhstan, Uzbekistan, Fossil Fuel, Solar and Wind Energy, Renewable Energy, Fossil Fuel*

Introduction

Historically characterized by a disproportionate dependence on fossil fuel resources, the energy picture in Central Asia has been dominated by the large-scale use of coal (over 50% of Kazakhstan's energy consumption) and natural gas (this makes up nearly 80% of Uzbekistan's supply). However, due to current global pressures (like climate change, energy security, and decarbonisation) a shift to alternative sources of energy (solar and wind energy) is emerging, taking advantage of the vast arid steppes in the region and existing wind corridors. Several criticisms have emerged, suggesting that the present level of and projections for this change might be insufficient to achieve the ambitious targets which have been set, with the continual existence of fossil fuel subsidies, as well as severe limitations in the capacity of the grid to support substantial new capacity for renewables. This paper asks the following research question: "How far will large-scale renewable solar and wind energy initiatives benefit Kazakhstan and Uzbekistan in terms of reducing their fossil fuel dependence, and what impacts will this have in terms of regional energy geography?" Through a detailed analysis of existing initiatives and plans and projections, this study reveals possible shifts in geography including new energy hub development and the creation of transnational grid links in a region which shows a clear readiness to move on to a sustainable energy transition.

Literature Review

Academic discussions pertaining to the energy transition occurring in Central Asia often highlight the contradiction that exists between established fossil fuel infrastructure and the new opportunities that renewable energy sources may provide (Walters, 2016).

Prior research shows that the energy matrix prevalent in Kazakhstan has been dominated by coal whereas Uzbekistan has heavily relied on natural gas, renewable sources contributing to less than 5% historically of their total energy supplies (Caporin et al., 2023). Furthermore, in scholarly investigations renewable energy is highlighted as solar and wind are feasible alternatives with much investment flowing from countries like China and the gulf states to counteract environmental externalities (Karatayev & Clarke, 2014). The comparisons that have been made highlight that Kazakhstan has been a pioneer in emissions trading whereas Uzbekistan has adopted hybrid energy models. However, these studies indicate that the development of renewable energy sources might be affected by existing fossil fuel subsidies and weaknesses in grid infrastructure. It emerges from the literature on energy geography that renewable energy development belongs to a new energy corridor construction, taking Caspian green energy exports as an example in that they will influence the established energy dependency to some extent but having an effect to strengthen the region's integration (Laldjebaev et al., 2021). In the existing literature on this topic, there is a lack of studies dealing with the post-2025 implications towards fossil fuel reduction of these projects. A more complete examination should be devoted to the geopolitical impact of a new type of energy gaining predominance, in particular dealing with new forms of dependency or those associated with possible obsolescence of established energy structures leading to a change of the surrounding power relationships. Some scholars, however, are sceptical about the scale of the effects that will occur and the speed with which transition will happen. They argue that deeply entrenched fossil fuel infrastructure, together with financial problems and political inertia, will operate together to limit the actual affect renewable energy projects will have on fossil fuel dependency and the energy geography of the region in the medium to short term. However, this does not eliminate the possibilities in the region, as Central Asia is rich in renewable energy options, with countries like Kazakhstan, Uzbekistan and Turkmenistan seeing this construction as a means whereby their oil and gas exports may be increased. As for Kyrgyzstan and Tajikistan they appear to regard renewable energy as a means of diminishing their dependency on energy imports (Kaliakparova et al., 2020). The great resource endowment of the region naturally produces possibilities for the development of this energy, especially since there is much solar and wind potential available and the position of Central Asia makes it strategically placed for a considerable transition towards the building up of sustainable forms of energy systems. However, considerable disparity exists in the speed of progress and range of achievable measures that can be applied in the various countries (Shadrina, 2019) (Radovanović et al., 2021).

Methodology

This qualitative comparative study was grounded in the secondary data collected by way of online search through to September 2025 and then was focused on renewable energy initiatives, the make-up of national energy supplies and their effects. Primary data sources included the International Energy Agency (IEA) reports, published government statements and peer-reviewed papers in academic journals. The basis of the analysis is the sizes of the different projects, the degree of renewable energy in the national electricity grids, the degree to which there was a decrease in dependence on fossil fuel, and changes in geography that resulted from it. Limitations identified included possible biases inherent in self-reporting and a predominance of English language sources; these were partially remedied by cross-checking of information.

Analysis

Large-Scale Solar and Wind Projects in Kazakhstan

The commitment of Kazakhstan to renewable energy resources is already reflected in various planned projects like a 185 MW solar power plant with 70 MW storage capacity to be commissioned in 2025 and to be developed by Jinko Power, plus the Mirny 1 GW onshore wind farm, scheduled to start construction in the autumn of 2025. These are part of a greater whole, including nine other plants in the next five years, all based on nine other large scale projects previously completed by 2024 (Mukatov & Khabibullin, 2018). A green hydrogen complex of $3.1 billion is under construction in conjunction with South Korea to further accelerate integration of the renewable resources. These projects, strategically centered, primarily in the south and around the Caspian sea, would increase to the use of renewable energy resources by 2030 to something like 15% of the total and more ambitiously about 50% of the energy mix by 2050, substantially reducing coal's large premium of 54% of the energy matrix relying entirely on fossil fuels losses disadvantageously in visual terms Finally, it is interesting say, early in 2025 renewable resources had reached 6.8% of the total energy resources in use, showing positive advances made in full terms of 85% reliance on fossil fuels (Ayubova, 2023). However, some academic perspectives consider the real transition and progress in the transition will be equivocal, giving rise to relatively pessimistic conclusions about the actual transition and effective transitions which could sell the use of renewable energy resources and re-positioning that part of the energy market that will need 'ochange in the more immediate to medium term but the problems with entrenched fossil fuel infrastructures, very large capital finance elements and political blocking factors to render a sudden implementation of serious and effective renewable energy incentives and policy incentives possible in the future.

Large-Scale Solar and Wind Projects in Uzbekistan

Uzbekistan's projects include Masdar's solar PV, Zarafshan's 500 MW wind, and Voltalia's 526 MW hybrid project with a 25-year PPA. China also adds 500 MW Farish solar plants and 2024's 1 GW wind plants to the $3 billion investments (Ayubova, 2023). Targets for 2026 are 4 GW each of solar and wind, 25 GW renewable by 2030, up from 0.1% of the past few years. By 2025 the renewables are aimed at 8.1 billion kWh, contrasting with gas's 79% of total. Despite remarkable potential for various energy sources such as hydropower, solar energy, wind energy, and geothermal energy relative to very limited deployment of these species in Central Asia, the local deployment of these energy carriers is low either mainly due to obsolete technology or institutional rigidity (Zhao et

al, 2023) (Laldjebaev et al, 2021). The reasonable potential, especially that for solar energy, derived from high solar irradiance amounts and long periods of sunshine, leads to a strong argument for the positive deployment of solar energy systems (Nasirov et al, 2023). Still, a few academic views are sceptical of the size and speed of projected energy transitions pointing out that the strong existing fossil fuel infrastructure and considerable amounts of finance, and political inertia will limit the real impact of the renewables on limiting fossil fuel dependence and radically changing energy geography in the region in the short to medium run. Uzbekistan's particular problem in reducing dependence on natural gas is severe, natural gas being forecast to account for 79% of total primary demand for energy by 2030, thus requiring sizeable and rapid shift to alternative energy sources to meet increased electricity demands and urban development (Kuklina & Galkina, 2023). The multifaceted strategy which Uzbekistan is pursuing to deal with this problem can include not only a large measure of shift to renewable sources of energy solar and wind power, but also very necessary modifications to the existing power grid and an implementation of energy efficiency measure throughout all sectors (Kamolov et al, 2025). This strategy involves co-operation with international bodies such as Asian Development Bank, World Bank to install utility scale solar and hydropower projects which involve tapping on Uzbekistan's considerable solar power (51 billion kWh annually (Ayubova, 2023)) which will resulting in a rampant increase in share of alternative energy sources to 25% by the year 2030 implying a great correct build-up of a renewable energy sources to about 5 GW over a ten year period. (Ayubova, 2023)

Impacts on Fossil Fuel Dependence

These developments may lessen dependence, since Kazakhstan's renewables would cut coal emissions, while Uzbekistan's hybrids would permit a diversification away from reliance on gas. Projections show that Kazakhstan will generate 15% renewables by 2030, eliminating 20-30% of fossil generation, if implemented at the right scale (Karatayev & Clarke, 2014). Uzbekistan's target of 40% renewables would reduce gas dependence by about a third, especially if there is the international financing for the move. Over 85% of the energy in both, however, still comes from fossil fuel sources, and impediments to full switch costs of inputs and grid considerations. Nevertheless, despite these developments, some academics express skepticism regarding the scale and speed of these transitions, arguing that entrenched fossil fuel infrastructure, compounding physical financial barriers and political inertia combine to ensure that the eventual impact of renewable energy projects upon the fossil fuel dependence and regional energy geography, will, in the short to medium term, be limited.

Alterations to Regional Energy Geography

Green corridors and exports brought by renewables have changed the geography, in this case to allow for the Azerbaijan-Kazakhstan-Uzbekistan Caspian cable for the transfer of green energy. Kazakhstan positions itself as a transit hub of energy, while Uzbekistan employs its desert solar farms to create new hubs for the same. This facilitates integration and reliance on fewer imports while also advancing toward the water-energy nexus in being able to use renewables better, in particular greater efficiency in renewables. Nonetheless, some scholars are sceptical as to the possible scale of this technology change, and are concerned about the pace of the same when compared to the existing fossil fuel giants standing in the way. The scale of such fossil fuel infrastructure may greatly inhibit (through the financial resources required) the impact of such renewables in overcoming the gross dependence upon fossil fuels as well as the hopes of a quite different regional energy geography brought by the renewable projects in the short to medium term. This scepticism is further varied by the "double paradox of plenty" experienced throughout Central Asia where economies rich in the wealth of fossil fuels are seeking to supply energy renewable (not hydropower) – where the poorer countries which presumably have more water behind the dams are continuing to rely on the large dams for energy requirements and power generation, which gives rise to considerable institutional difficulties, and economic constraints impeding the widespread use of new renewable energy resources possibilities (Shadrina, 2020).

Aspect	Kazakhstan	Uzbekistan
Current Renewables Share (2025)	6.80%	~1-2% (aim 20% by 2025)
Fossil Dependence	85% (coal 54%)	90%+ (gas 79%)
Key Projects	Mirny (1GW wind), 185 MW solar	Voltalia (526 MW hybrid), Masdar (500 MW wind)
Targets	15% by 2030, 50% by 2050	8 GW by 2026, 40% by 2030
Fossil Reduction Potential	Moderate (20-30% by 2030)	Significant (1/3 gas cut)
Geographical Changes	Transit hub, Caspian exports	Desert hubs, regional trading

Discussion

While projects help to lower dependence on fossil fuels, achieving total decarbonization is going to be a complex task with obstacles such as constant fossil fuel subsidies and infrastructure upgrades that are required for the transmission networks. Geographically, the growth of renewable energy resources is going to help the sustainable energy centers to be formed as well as improve regional integration; however, the uneven development of renewable energy resources and investment patterns may bring about new imbalances in economies and energy

supplies. International collaboration on projects like the Uzbek-Kazakh-German r&d labs for renewable energy technologies, is something that is essential to speed up this transition and mitigate potential disparities. On the flip side, critics argue that the high up-front capital costs of large renewable energy projects, as well as the fact that solar and wind power are both inconsistent sources of energy give rise to major problems of instability and uncertainty regarding the electricity grid, and may possibly result in a demand for fossil fuels to guarantee baseload power.

Conclusion

Large solar and wind farms are a major but only partial solution to Kazakhstan and Uzbekistan's future dependence on fossil fuels in 2030 and beyond, with growing impacts up to 2050. They will change the energy map of the two countries through the creation of more intensive green energy corridors and the enhancement of cross-border energy trading. The effective transformation of such will be very much dependent on the efficient policy co-ordination and the provision of adequate finances. Further studies will be very important to discuss and evaluate positive developments which take place after the year 2030 of the schemes for renewal of energy in Kazakhstan and Uzbekistan. Critics argue that the enormous initial capital expenditure required for such large capital renewable projects, along with the intermittent solar and wind power supply, will create problems of grid stability and security of supply, which may increase the dependency on fossil fuels as the source of baseload power.

Acknowledgment

I, Rakesh Kumar, Asst. Prof, Dept. of Geography, Murarka College, Sultanganj, TMBU, Bhagalpur do hereby confirm that there has been no financial support extended to me by any institution to carry out these works and also that there has been no Conflict of Interest to carry out these works and get published.

Financial support and sponsorship

Nil.

Conflicts of interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

References

1. Ayubova, I. (2023). Transition to alternative sources of electricity supply: diversifying the energy strategy in the Republic of Uzbekistan. *E3S Web of Conferences*, *461*, 1072. https://doi.org/10.1051/e3sconf/202346101072
2. Caporin, M., Cooray, A., Kuziboev, B., & Yusubov, I. (2023). New insights on the environmental Kuznets curve (EKC) for Central Asia. *Empirical Economics*, *66*(5), 2335. https://doi.org/10.1007/s00181-023-02520-9
3. Kaliakparova, G. S., Gridneva, Y. E., Assanova, S. S., Sauranbay, S. B., & Saparbayev, A. (2020). INTERNATIONAL ECONOMIC COOPERATION OF CENTRAL ASIAN COUNTRIES ON ENERGY EFFICIENCY AND USE OF RENEWABLE ENERGY SOURCES. *International Journal of Energy Economics and Policy*, *10*(5), 539. https://doi.org/10.32479/ijeep.9962
4. Kamolov, A., Turakulov, Z., Norkobilov, A., Variny, M., & Fallanza, M. (2025). Regional Resource Evaluation and Distribution for Onshore Carbon Dioxide Storage and Utilization in Uzbekistan. *Greenhouse Gases Science and Technology*. https://doi.org/10.1002/ghg.2325
5. Karatayev, M., & Clarke, M. L. (2014). Current Energy Resources in Kazakhstan and the Future Potential of Renewables: A Review [Review of *Current Energy Resources in Kazakhstan and the Future Potential of Renewables: A Review*]. *Energy Procedia*, *59*, 97. Elsevier BV. https://doi.org/10.1016/j.egypro.2014.10.354
6. Kuklina, A., & Galkina, A. N. (2023). New challenges for Uzbekistan's energy sector and the role of the gas industry. *E3S Web of Conferences*, *470*, 1009. https://doi.org/10.1051/e3sconf/202347001009
7. Laldjebaev, M., Isaev, R., & Саухимов, А. (2021). Renewable energy in Central Asia: An overview of potentials, deployment, outlook, and barriers. *Energy Reports*, *7*, 3125. https://doi.org/10.1016/j.egyr.2021.05.014
8. Mukatov, B., & Khabibullin, R. (2018). Renewable energy sources in future energy balance of the republic of Kazakhstan. *E3S Web of Conferences*, *58*, 3006. https://doi.org/10.1051/e3sconf/20185803006
9. Nasirov, T., Trofimov, G., Khamidov, Sh. V., & Tanirbergenov, R. (2023). Problems of ensuring reliability and sustainable development of the United energy system of Central Asia under the conditions of energy consumption growth. *E3S Web of Conferences*, *461*, 1038. https://doi.org/10.1051/e3sconf/202346101038
10. Radovanović, M., Filipović, S., & Panić, A. A. (2021). Sustainable energy transition in Central Asia: status and challenges. *Energy Sustainability and Society*, *11*(1). https://doi.org/10.1186/s13705-021-00324-2
11. Shadrina, E. (2019). *Renewable Energy in Central Asian Economies: Role in Reducing Regional Energy Insecurity. 993.* https://www.adb.org/sites/default/files/publication/522901/adbi-wp993.pdf
12. Shadrina, E. (2020). A double paradox of plenty: renewable energy deployment in Central Asia. *Eurasian Geography and Economics*, *63*(1), 1. https://doi.org/10.1080/15387216.2020.1823868
13. Walters, J. (2016). Managing the Energy Transition. *Global Journal of Emerging Market Economies*, *8*(2), 81. https://doi.org/10.1177/0974910116634493
14. Zhao, C., Liu, B., Wang, J., Xue, R., Shan, Y., Cui, C., Dong, X., & Dong, K. (2023). Emission accounting and drivers in Central Asian countries. *Environmental Science and Pollution Research*, *30*(46), 102894. https://doi.org/10.1007/s11356-023-29608-0