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The Problems of Hydropower: Charting a Sustainable Energy Pathway for Central Asia

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Executive summary

In recent years, Central Asian states have experienced a simultaneous water and energy crisis. Several states have sought to harness their hydropower potential in response to the region's aging energy infrastructure and rolling blackouts. However, increasing climate change induced water shortages have rendered hydropower an unsustainable solution in the long term. Therefore, Central Asian countries should:

1. Accelerate the development of non-hydropower renewable sources and increase upfront capital investments in wind, solar, and nuclear power.

2. Reform their national development strategies and legal frameworks to attract foreign investment to these sectors.

3. Cease subsidising hydrocarbons to improve the economic viability of renewables.

4. Improve regional energy cooperation to enhance the efficiency of their energy grids and prevent blackouts.

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Introduction

Since independence, Central Asian countries have faced a water and energy crisis. Several states have struggled to maintain year-round electricity supplies. Uzbekistan is experiencing rapid population growth and surging energy demand, exerting immense pressure on the country's gas reserves. In 2023, the country temporarily halted gas exports to China and imported 2.8 billion cubic metres of gas from Russia.[1] In 2024, gas exports continued to fluctuate as Uzbekistan sought to balance domestic demand with its preexisting gas deal with China which requires it to deliver 10 billion cubic metres annually.[2] Kazakhstan has also suffered from intermittent blackouts. In October 2021, Ekibastuz-1, Ekibastuz-2, and the Aksu power plant were shut down, leading to the loss of more than 1000 megawatts of power.[3] Tajikistan and Kyrgyzstan also endure rolling blackouts, especially during the winter months. In 2023, Kyrgyzstani President Sadyr Japarov declared a state of emergency in the energy sector until 2026, as the country's hydropower production continues to decline due to the need to modernise older plants, such as the Toktogul HPP.[4] Overall, the region's ageing power plants, crumbling transmission network (primarily constructed during the Soviet period), and surging demand are to blame.

At the same time, Central Asia is confronting a growing water crisis. Generally, the region can be divided into downstream (Kazakhstan, Uzbekistan, and Turkmenistan) and upstream (Kyrgyzstan and Tajikistan) riparian countries. During the Soviet period, a division of

1 Meray Ozat, "Central Asia's Escalating Energy Crisis and its Geopolitical Implications," *Caspian Policy Centre,* September 8, 2023, https://www.caspianpolicy.org/research/energy-and-economy-program-eep/central-asias-escalating-energy-crisis-and-its-geopolitical-implications.

2 Ibid.

3 Bruce Pannier, "The Curious Case of Central Asia's Electricity Shortages," *RadioFreeEurope/RadioLiberty,* November 16, 2021, https://www.rferl.org/a/central-asia-severe-electricity-shortages/31564293.html.

4 Ibid.

labour developed regarding agriculture and electricity generation. In summer, upstream countries released water from their dams to facilitate irrigation and provide electricity to the downstream countries. In winter, upstream countries reduced the flow to store water for summer irrigation in return for oil, gas, and electricity from downstream countries to meet their energy needs. However, the Soviet system initially maintained after independence in the February 1992 Almaty Agreement on Cooperation in the Field of Joint Water Resources Management and Conservation of Interstate Sources, has been undermined as several countries have gradually withdrawn from the agreement, leading to the collapse of the region's unified power system in 2009.[5] As a result, upstream countries like Tajikistan and Kyrgyzstan have had to burn increasing quantities of coal during the winter months to stave off blackouts despite their extensive renewable resources.[6]

In recent years, the region has witnessed a series of prolonged droughts (2008, 2014, 2017, 2018, 2020, 2021, 2022, 2023) and an increase in natural disasters affecting agriculture and hydropower generation.[7] The Institute of Water Problems and Hydro-Energy at the National Academy of Sciences in Kyrgyzstan found that the melting of glaciers has increased threefold compared to 1950.[8] Upwards of 20% of the country's glaciers have melted in recent decades, threatening water shortages that could undermine the region's energy systems and agriculture.[9]

Poor irrigation also contributes to water shortages, with the United Nations Development Programme (UNDP) reporting that Central Asia loses $1.7 billion annually due to poor water management, reducing crop yields.[10] Thus, in Central Asia, the negative consequences of climate change are being felt more acutely due to the region's poor water management and its inefficient and water-intensive agriculture.

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5 Luis Izquierdo, Mari Stangerhaugen, Diana Castillo, Robert Nixon and Gloria Jimenez, "Water Crisis in Central Asia: Key Challenges and Opportunities," *Graduate Program in International Affairs, New School University* (2010), 7.

6 Farkhod Aminjonov, "Renewable Energy Sources in Central Asia: What Should Be on the Agenda Now," *CABAR.asia* (2020), 8.

7 Asel Murzakulova, "The Impact of Climate Change on Central Asian Hydro-Politics," *Graduate School of Development: Mountain Societies Research Institute, University of Central Asia* (2023), 4.

8 Izquierdo, Stangerhaugen, Castillo, Nixon and Jimenez, "Water Crisis in Central Asia: Key Challenges and Opportunities," 16.

9 Ibid.

10 "Bringing Down Barriers: Regional Cooperation for Human Development and Human Security," in Central Asia Human Development Report, (UNDP Regional Bureau for Europe and the Commonwealth of Independent States, 2005).

Policy Challenge

Various solutions have been proposed for this crisis. Scholars and policymakers alike have advanced the construction of more hydroelectric power plants (HPP) and energy swaps to overcome their reliance on coal.[11] Indeed, several countries, especially Kyrgyzstan and Tajikistan, have invested heavily in hydropower. While they already receive nearly 90% of their electricity from hydropower,[12] estimates indicate that they have only developed 4% and 10% of their hydropower capacity, respectively.[13] Numerous HPP projects have been announced in recent years. In 2016, Tajikistan recommenced the construction of the Rogun HPP, which will generate 3600 megawatts, doubling Tajikistan's electricity generation capacity.[14] While these plans initially caused consternation among downstream countries reliant on irrigation to cultivate their water-intensive crops, a new era of cooperation followed the death of Islam Karimov, with Uzbekistan and Kazakhstan investing in new HPPs, such as Kyrgyzstan's Kambar-Ata project, in exchange for some control over water flows and electricity exchanges.[15] External powers are also investing in the region's hydropower, with China pledging $2-3 billion to construct the Kazarman HPP.[16] Thus, Central Asian states are heavily investing in their hydropower capacity in response to rising energy demand.

However, Central Asia's worsening water and environmental crisis threatens the expansion of hydroelectric power. As mentioned above, droughts have increased in frequency in recent years, and reservoir levels have fallen. There are growing concerns about the impact of large HPPs on river ecosystems. Ecologists have noted that the Syr Darya basin already contains over 100 large dams, and there are plans to construct 70 more.[17] Overusing the river's resources will lead to an

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11 For example, see Aminjonov, "Renewable Energy Sources in Central Asia: What Should Be on the Agenda Now," 16.

12 Aminjonov, "Renewable Energy Sources in Central Asia: What Should Be on the Agenda Now," 17.

13 Maxwell Zandi, "Central Asia's Clean Energy Opportunity: Hydropower," *Atlantic Council,* June 2, 2023, https://www.atlanticcouncil.org/blogs/energysource/central-asias-clean-energy-opportunity-hydropower/.

14 Ibid.

15 Saniya Sakenova, "Kazakhstan Signs Agreement on Construction of Kambar-Ata Hydro-Electric Plant," *The Astana Times,* June 12, 2024, https://astanatimes.com/2024/06/kazakhstan-signs-agreement-on-construction-of-kambar-ata-hydroelectric-power-plant/.

16 Ozat, "Central Asia's Escalating Energy Crisis and its Geopolitical Implications."

17 Evgeny Simonov, "Inefficient hydroelectric power plants, irrational irrigation and corruption. What is killing the Syr Darya and how to resist it," interview by Petr Trotsenko, August 28, 2024, https://centralasiaclimateportal.org/inefficient-hydroelectric-power-plants-irrational-irrigation-and-corruption-what-is-killing-the-syr-darya-and-how-to-resist-it/.

ecological catastrophe and has already led to the disappearance of numerous unique species like the Syr Darya false shovelnose. Therefore, if large-scale hydropower is not a realistic long-term solution, what can be done to resolve the region's environmental and energy crisis?

Policy Options

1. Small HPPs

Noting the problematic nature of large HPP projects, several experts have advanced alternative solutions to the environmental and energy issues faced by the region. Some experts have proposed the development of modular small-scale run-of-the-river HPPs that would operate in irrigation canals and other small waterways.[18] Small HPPs could better serve remote areas where extending the grid network would be difficult. They could also be combined with other renewable energies, such as solar and wind, to maintain the electrical balance in the network. Moreover, they could be constructed through public-private partnerships as advanced by Uzbekistan and Kazakhstan in recent years.

Nevertheless, these small HPPs would have to deal with many of the same issues as their larger counterparts, like increasing droughts and water shortages. Several reports from CABAR and the CAREC Institute have estimated that Central Asia could lose 80% of its glaciers by the end of the century.[19] As glaciers account for 20% of all water flow to significant rivers in the wet season and 75% during the dry season, a severe reduction in the size and number of glaciers entails a dramatic decline in water availability.[20] For instance, 60% of the small HPPs Tajikistan constructed from 2012 to 2016 were built to draw water from sources that have since dried up.[21] Thus, non-hydropower renewable energy sources must be developed in Central Asia where water shortages are increasingly a given.

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18 For example, see Ulugbek Azimov and Nilufar Avezova, "Sustainable small-scale hydropower solutions in Central Asian countries for local and cross-border energy/water supply," *Renewable and Sustainable Energy Reviews* 167 (2022): 1-14.

19 Aminjonov, "Renewable Energy Sources in Central Asia: What Should Be on the Agenda Now," 17.

20 Ibid.

21 Ibid.

2. Non-Hydropower Renewable Energy

In an effort to diversify away from their dependency on hydrocarbons and hydropower, Central Asian states should significantly invest in other renewable sources such as wind and solar. According to a recent UN information brief, non-hydropower renewable energy accounts for less than 1% of North and Central Asia's (Russian Siberia, the Caucasus, and Central Asia) energy supply.[22] Nevertheless, in recent years, several Central Asian states, especially Kazakhstan, have successfully endeavoured to expand their renewable energy production. In 2018, Kazakhstan had 60 functioning renewable energy projects, with several others under construction.[23] By 2020, Kazakhstan had constructed 19 wind and 31 solar power plants, with 3% of Kazakhstan's total electricity coming from renewable sources.[24]The country also has ambitious plans to increase the share of renewable energy to 50% by 2050.[25]

Nevertheless, the countries in the region lack the financial resources to fund their green energy transitions. For instance, in Kazakhstan, up to 70% of renewable energy projects are financed by foreign direct investment (FDI).[26] The countries in the region have sought to benefit from global initiatives such as China's Belt and Road Initiative. However, only 2.62% of Chinese FDI in Kazakhstan and 4.3% in Uzbekistan were invested in renewable energy projects.[27] Given this reliance on FDI, Central Asian states must simplify and clarify investment rules and procedures. Overall, Central Asian countries should also be cautious about relying on specific external powers for renewable technologies as this could develop into a broader geopolitical dependency.

Several factors limit the ability of Central Asian states to attract international capital, most notably the lack of regulation and

22 ESCAP, UN, "Information brief: energy prospective in North and Central Asia," (2015), 2.

23 Elena Shadrina, "Non-hydropower renewable energy in central Asia: assessment of deployment status and analysis of underlying factors," *Energies* 13, no. 2963 (2020): 10.

24 Aminjonov, "Renewable Energy Sources in Central Asia: What Should Be on the Agenda Now," 10.

25 Aminjonov, "Renewable Energy Sources in Central Asia: What Should Be on the Agenda Now," 9.

26 Shadrina, "Non-hydropower renewable energy in Central Asia: Assessment of deployment status and analysis of underlying factors," 14.

27 Shadrina, "Non-hydropower renewable energy in Central Asia: Assessment of deployment status and analysis of underlying factors," 15.

the glaring inconsistencies in national development documents. Significant gaps exist between official goals and the strategies outlined to achieve them, with Tajikistan offering the clearest example of these contradictions. The country's Programme for Development in the Mid-Term Perspective 2016–2020 highlights its underdeveloped energy sector and the limited access to electricity in remote areas.[28] It recommends developing the solar, wind, and biomass sectors to diversify its electricity supply. However, the Power Sector Development Master Plan 2017 emphasises the development of the hydro-power sector and states that wind and solar are not priority areas.[29] Thus, to facilitate investment, states across the region must refine their development goals.

While Central Asian countries have immense renewable energy potential, their governments are heavily dependent on foreign capital to fund their transition yet have done little to develop the necessary legal frameworks to attract such investments. For instance, Uzbekistan has frequently concluded agreements with international investors, such as Siemens Gamesa and Etka Co Enerji, before cancelling them at a later date.[30] They have also delayed the construction of five solar power plants funded by the Asian Development Bank.[31] While initial feasibility studies were being completed, crucial technologies developed or became cheaper, leading the government to cancel the previous tender before issuing a new one to benefit from this reduction in cost. The entire process then repeated itself. Investors require clear rules and the protection of their rights. Uzbekistan cannot expect to meet its renewable energy goals while waiting for cheaper prices. Thus, to boost investment in renewables, Central Asian states need to clarify the rules of the game and avoid the arbitrary cancellation of projects.

Central Asian states' continued subsidising of fossil fuels impedes the region's green transition. Due to subsidies, the cost of non-hydropower renewables remains four or five times higher

28 Shadrina, "Non-hydropower renewable energy in Central Asia: Assessment of deployment status and analysis of underlying factors," 11

29 Ibid.

30 Aminjonov, "Renewable Energy Sources in Central Asia: What Should Be on the Agenda Now," 15.

31 Ibid.

than hydrocarbons.[32] While subsidising traditional fuel sources may buy these regimes political support, it does little to support the economic viability of the energy transition.

Kazakhstan and Uzbekistan have, however, introduced feed-in tariffs to support renewable projects.[33] Feed-in tariffs are designed to encourage investment in renewable energies by guaranteeing fixed payments to producers for the electricity they generate. While Uzbekistan relies on power purchase agreements (PPAs), Kazakhstan replaced its feed-in tariff system with the Settlement and Financial Centre for Renewable Energy Support in 2018, which purchases electricity from renewable energy providers at fixed rates at auction.[34] This approach ensures a steady revenue stream for providers, making investments in renewable energy more attractive. However, the effectiveness of these tariff measures will remain limited unless non-renewable energy prices are liberalised.

As mentioned above, some countries in the region have also initiated auctions for renewable energy projects.[35] Overall, competitive bidding should reduce costs and improve the efficiency of these projects. In recent years, Kazakhstan has also moved to index auction prices in line with fluctuations in the national currency and other economic indicators.[36] These measures should improve the feasibility of renewable projects. They should be adopted in other countries in the region, such as Turkmenistan and Tajikistan, where non-hydropower renewable energy remains less developed.

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32 Shadrina, "Non-hydropower renewable energy in central Asia: assessment of deployment status and analysis of underlying factors," 6.

33 "The Law About Support the Use of Renewable Energy Sources," *The International Energy Agency,* January 24, 2022, https://www.iea.org/policies/5407-the-law-about-support-the-use-of-renewable-energy-sources-amended; "Possible Barriers to the Deployment of Solar Energy in Uzbekistan," *The International Energy Agency,* 2022, https://www.iea.org/reports/solar-energy-policy-in-uzbekistan-a-roadmap/possible-barriers-to-the-deployment-of-solar-energy-in-uzbekistan.

34 "About the Company," *The Settlement and Financial Centre for Renewable Energy Support,* https://rfc.kz/en/about/about-company/.

35 "The Law About Support the Use of Renewable Energy Sources," *The International Energy Agency,* January 24, 2022; "Support for the Development of Wind Auctions in Uzbekistan," *The European Bank for Reconstruction and Development,* file:///C:/Users/Harry%20Fennell/Downloads/77670_TOR.pdf.

36 Louis Skyner, "Uzbekistan's Energy Transition Depends on Systematic Reforms," *Bourse and Bazaar Foundation,* February 21, 2025, https://www.bourseandbazaar.org/articles/2025/2/21/uzbekistans-transition-depends-on-structural-reforms.

As mentioned above, several states, especially Uzbekistan, have created public-private partnerships to develop the renewable energy sector. For instance, experts have estimated that Uzbekistan will have to spend roughly $200 billion to achieve net zero by 2060. Most of these funds will have to come from private investors. The strategic involvement of the state and developmental financial institutions can reduce some of the risks to private capital, thus facilitating investment.

Governments should consider implementing autonomous renewable energy systems. While most communities in the region are connected to a central energy system, many remote areas are not. As a result, these communities often rely on coal for heating and electricity generation. According to CABAR, 84% of coal consumers in Kazakhstan live in rural areas.[37] To address this dependence on coal, states must incentivise the installation of renewable energy systems in residential premises. For instance, Uzbekistan exempts individuals from property tax for three years if they install solar panels or any other renewable energy system that operates independently from the central grid on the property they own.[38]

Therefore, to incentivise the expansion of renewable energy throughout the region, governments must clarify their investment regulations and development strategies. They should also implement competitive tendering processes, public private partnerships, guaranteed energy purchases, and subsidies for autonomous renewable energy systems to improve efficiency and reduce the possibility of corruption and waste.

3. Nuclear

Despite the controversial legacy of Soviet nuclear tests in the region, several Central Asian states have turned to nuclear power to address their energy woes. In October 2024, Kazakhstan held a referendum that approved the construction of the country's first nuclear power plant (NPP).[39] Uzbekistan has also announced

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37 Aminjonov, "Renewable Energy Sources in Central Asia: What Should Be on the Agenda Now," 11.

38 "Possible Barriers to the Deployment of Solar Energy in Uzbekistan," *The International Energy Agency,* 2022.

39 Catherine Putz, "Nuclear Power Referendum Passes in Kazakhstan," *The Diplomat,* October 7, 2024, https://thediplomat.com/2024/10/nuclear-power-referendum-passes-in-kazakhstan/.

that it intends to work with Rosatom (Russia's nuclear energy corporation) to build the region's first NPP, which will involve the construction of several small modular nuclear reactors (SMR).[40] Kyrgyzstan also signed a similar agreement to construct a 300 megawatt SMR with Rosatom.[41] Overall, nuclear power could help to reduce the region's energy deficits without damaging the environment.

While SMR technology has been around for decades, it has been primarily used for military purposes and has not been adapted to civilian use. Generally, SMRs produce 300 megawatts and are significantly smaller than traditional NPPs.[42] They also require less cooling water than traditional NPPs, an essential factor considering the region's water shortages. Many such reactors can often rely on passive cooling systems alone. They are modular and can be prefabricated in factories before being assembled on site, reducing construction costs and time. They also do not require the same extensive transmission networks as regular NPPs, meaning they can be situated in more remote areas. Overall, they are well-suited to balancing electricity grids when other renewable resources are down.

However, SMR technology is not without significant drawbacks. SMRs still produce significant amounts of nuclear waste, although certain SMRs have been designed to operate for around 60 years without refuelling.[43] Nevertheless, countries should ensure they have established the proper methods for managing nuclear waste when adopting this technology. Several experts doubt whether they are more efficient than other renewable sources or larger NPPs.

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40 Nicholas Castillo, "Across Central Asia, Governments Bet Big on Nuclear Power," *Caspian Policy Centre,* August 30, 2024, https://caspianpolicy.org/research/energy/across-central-asia-governments-bet-big-on-nuclear-power.

41 Ibid.

42 Jasmina Vujić, Ryan M. Bergmann, Radek Škoda, and Marija Miletić, "Small modular reactors: Simpler, safer, cheaper?" *Energy* 45, no. 1 (2012): 288.

43 Vitaly Fedchenko, "Small modular reactors may have climate benefits, but they can also be climate-vulnerable," *Stockholm International Peace Research Institute,* January 26, 2024, https://www.sipri.org/commentary/blog/2024/holding-page-vitalys-blog-smrs-and-climate-vulnerability

Recommendations

1. The countries in the region need to diversify their energy production away from hydrocarbons and large-scale hydropower. They should invest more in small HPPs while conducting more rigorous climate feasibility studies so that their water sources do not run dry, as has been the case in Tajikistan.

2. Governments should prioritise the development of non-hydropower renewables, such as wind and solar. In addition, they could consider the construction of small modular nuclear reactors if they can address the efficiency and waste issues.

3. Regional governments should avoid developing dependencies on specific countries for renewable technology when looking to attract the required financing.

4. Regional governments must resolve the contradictions in their respective national development strategies and legal frameworks to attract investment and guarantee the efficient implementation and supervision of energy projects.

5. Central Asian governments should end subsidies for traditional hydrocarbons that render renewable energy sources uneconomical.

6. Central Asian states should also engage in greater regional cooperation in the energy sector. Rather than the current ad hoc bilateral agreements that govern energy relations, they should reconstruct a unified electricity system that would facilitate the import and export of electricity, thus efficiently balancing national energy grids and preventing blackouts.

Conclusion

In recent years, Central Asia's water crisis and energy crisis have worsened. Central Asian states experience regular electricity blackouts due to rapid economic and population growth and the region's crumbling energy infrastructure. Many countries, especially Tajikistan and Kyrgyzstan, have turned to hydropower to overcome these

deficiencies. However, increasing water shortages render many large-scale hydropower projects unviable in the long term. Therefore, Central Asian states should concentrate investment in other renewable energy sources like wind and solar.

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