Kazakhstan's Energy Transition

Not Such a "Peaceful Atom"

In the sleepy township of Ulken along Lake Balkhash in southeastern Kazakhstan, a simmering debate came to a boil on 21 August 2023. At a crowded public meeting at Ulken high school to discuss the government's plans to build the country's first nuclear power plant since the 1990s at the village, tensions were running high.

Environmental activists who had travelled from Almaty to Ulken made their opposition plain, "We are against the nuclear power plant, it will destroy Balkhash Lake!".[1]

"We residents have been waiting for this construction for 40 years… we spent days without heat and electricity…. Ulken needs this energy… Energy is scarce and very expensive in our country. We all need electricity. We support the peaceful atom!" one Ulken resident countered.[2]

Kazakhstan has long relied on its massive reserves of fossil fuels to feed its energy needs. Now sandwiched between rising energy demands and its goal of net-zero emissions by 2060, the government was turning to renewable and alternative energy to replace hydrocarbons. As the world's biggest producer of uranium widely used for nuclear fission, nuclear energy, sometimes referred to as the "peaceful atom", appeared to be a sensible option. Many Ulken residents also saw the nuclear power plant as bringing long-awaited economic development to the village.

To environmentalists however, the nuclear power plant was a threat to the waters and ecology of Lake Balkhash, which also served as a reservoir for Almaty, the country's economic capital. The shadow of hundreds of nuclear weapons tests conducted in Kazakhstan by the Soviet Union in the past, with long term consequences for Kazakhstan's population and environment, also loomed large.

Amid the public controversy, Kazakhstan President Kassym-Jomart Tokayev announced that a national referendum would be held to decide the fate of the proposed nuclear power plant.[3] Nuclear energy was only one prong of Kazakhstan's energy transition strategy, but it underscored some of the challenges the country faced. For a country used to tapping its vast store of hydrocarbons, how could Kazakhstan decarbonise its energy value chain for a more sustainable future?

Impetus to Decarbonise

A country with abundant coal, oil and natural gas resources, Kazakhstan was producing on average 2.3 times more energy than it needed domestically each year over the past two decades.[4] Not surprisingly, more than 95% of the country's domestic energy needs came from fossil fuels, primarily coal and, increasingly gas in

[1] Petr Trotsenko, "'Peaceful atom' sparks fierce debate in Kazakh village slated to host nuclear power plant," *RadioFreeEurope/RadioLiberty*, August 28, 2023, https://www.rferl.org/a/kazakhstan-nuclear-power-plant-debate-construction/32563042.html
[2] Trotsenko, "'Peaceful atom' sparks fierce debate."
[3] Assel Satubaldina, "Kazakhstan to Hold Referendum on Nuclear Power Plant Construction," *The Astana Times*, September 1, 2023, https://astanatimes.com/2023/09/kazakhstan-to-hold-referendum-on-nuclear-power-plant-construction/
[4] International Energy Agency (IEA), *Kazakhstan 2022 Energy Sector Review* (Paris: OECD Publishing, 2022), 11, https://doi.org/10.1787/73d1d69f-en

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recent years. This heavy reliance on fossil fuels meant that energy-related emissions are high – around 80% of the country's total greenhouse gas (GHG) emissions in 2020, excluding effects of land use change.[5]

Carbon dioxide (CO_2) produced primarily from burning of fossil fuels is the most prevalent GHG. Although Kazakhstan's annual CO_2 emissions from fossil fuels and industry almost halved in the 1990s due to the economic upheaval of the collapse of the Soviet Union, it started to climb again when the economy stabilised in 2000s (Figure 1 in Annex). By the mid-2010s, its CO_2emissions were on par with the level in the 1990. In 2022, Kazakhstan's CO2 emissions stood at 271.18 million tonnes. CO_2 emissions per capita in 2022 was 14 tonnes, higher than its Central Asian neighbours, or high-income countries' average of 10.1 tonnes (Figure 2 in Annex).[6] Kazakhstan has yet to decouple its economy from CO_2 emissions (Figure 3 in Annex). Globally, it was one of the most carbon-intense economies,[7] while its energy sector had the fourth highest carbon intensity.[8] In particular, electricity and heat generation accounted for almost 52% of total CO_2 emissions in 2021 (Figure 4 in Annex).[9]

The country's geography is characterised by steppes, semi-arid and desert zones, and low precipitation. According to Kazakhstan's Climate Change Action Report released in December 2022, climate change is making the country hotter.[10] From 1991 to 2020, the country's annual temperature increased by almost 1°C.[11] Like the rest of the region, climate change will further stress Kazakhstan's water situation. Most of the glaciers which serve as water sources may disappear by the end of the century, and coupled with higher rates of evapotranspiration, the country could face shortfalls of up to 50% of its water needs by 2040.[12] One study estimated that approximately 76.1% of Kazakhstan are desertification-sensitive areas, of which 18.3% are considered highly and very highly sensitive areas, with climate change partially responsible for promoting desertification.[13]

Kazakhstan's climate vulnerability especially in terms of human habitat loss, and stresses on economy and natural resources, was assessed as "severe" in 2010, and in the absence of action, would deteriorate to "acute" by 2030, according to DARA's Climate Vulnerability Monitor 2010.[14] A World Bank report projected that climate shocks could contract Kazakhstan's economy by 1.6% by 2050, increase poverty by 3%, and contract real wages by 2.1%.[15] As one of the world's largest wheat producers, the Ministry of Energy warned

[5] IEA, *Kazakhstan 2022*, 102.
[6] "Per capita CO_2 emissions," Our World in Data, accessed March 13, 2024, https://ourworldindata.org/explorers/co2?time=1990..latest&facet=none&Gas+or+Warming=CO%E2%82%82&Accounting=Territorial&Fuel+or+Land+Use+Change=All+fossil+emissions&Count=Per+capita&country=OWID_WRL~KAZ~High-income+countries
[7] "Carbon intensity: CO_2 emissions per dollar of GDP, 2018," Our World in Data, accessed March 13, 2024, https://ourworldindata.org/grapher/co2-intensity
[8] Asian Development Bank, *CAREC Energy Outlook 2030* (Manila: ADB, 2022), 112, https://dx.doi.org/10.22617/TCS220577-2
[9] "Kazakhstan: Emissions," IEA, accessed April 11, 2024, https://www.iea.org/countries/kazakhstan/emissions#what-are-the-main-sources-of-co2-emissions-in-kazakhstan
[10] "Reducing temperatures: Kazakhstan takes action against climate change," UNDP, last modified May 12, 2023, https://www.undp.org/kazakhstan/news/reducing-temperatures-kazakhstan-takes-action-against-climate-change
[11] UNDP, "Reducing temperatures".
[12] "The climate change impact on water resources in Kazakhstan," UNDP, last modified October 26, 2021, https://www.undp.org/kazakhstan/stories/climate-change-impact-water-resources-kazakhstan#:~:text=The%20state%20of%20water%20resources,50%20percent%20of%20its%20needs
[13] Yunfeng Hu, Yueqi Han, Yunzhi Zhang, "Land desertification and its influencing factors in Kazakhstan," *Journal of Arid Environments* 180 (September 2020): 5, https://doi.org/10.1016/j.jaridenv.2020.104203.
[14] DARA and the Climate Vulnerability Forum, *Climate Vulnerability Monitor 2010: The State of the Climate Crisis*, 2010, https://daraint.org/climate-vulnerability-monitor/
[15] Anna Bjerde and Tatiana Proskuryakova, "Climate Action Can Catalyze Kazakhstan's Economic Diversification. Inaction Will Be Costly," *The World Bank*, November 4, 2022, https://www.worldbank.org/en/news/opinion/2022/11/04/climate-action-can-catalyze-kazakhstan-economic-diversification-inaction-will-be-costly

that if farming practices did not change, climate change could reduce annual wheat harvest by as much as 49% by 2050.[16]

The government also had other motivations for pursuing low-carbon green growth.[17] Its economy was vulnerable to sharp price fluctuations in commodity markets, and low-carbon development was seen as an opportunity to attract international investments and stimulate regional development within the country. Under its 2013 "Concept for Transition to a Green Economy" (Green Economy Concept), the government projected that GDP would increase by 3% and more than 500,000 new jobs would be created by 2050.[18] On the other hand, procrastination would be costly. According to the World Bank report, Kazakhstan's economy could see long-term growth shrink by 2–2.5% a year if it did nothing while the rest of the world decarbonised.[19]

With the highest per capita GDP in Central Asia, Kazakhstan also saw itself as the regional leader in addressing climate change to "unite regional efforts towards achieving green growth".[20] The country was ahead of the pack by being an early adopter of renewable energy policies and had pioneered an Emissions Trading Scheme (ETS) in 2013. Low-carbon development would bolster its image domestically as a strong state capable of dealing with major risks like climate change, and internationally as a progressive and reliable partner.[21] Yet despite having the region's highest potential in renewables, particularly wind and solar, its economy was more energy- and carbon-intensive than several other former Soviet republics. There was growing acknowledgement that, as President Tokayev put it, the "current approach has largely exhausted itself".[22]

Policy Moves Towards a Low-Carbon Economy

The government signalled its intention to transition Kazakhstan towards a low-carbon economy through various official documents and international treaties. One of the most prominent was the government's unconditional target to keep GHG emissions 15% below the 1990 level by 2030 under the landmark 2015 Paris Climate Agreement[23] (see Table 1). Kazakhstan also set a conditional target of 25% reduction in GHG emissions by 2030, provided it had access to additional international investments, low carbon technology transfer mechanisms, green climate funds, and flexible mechanisms for countries in economic transition.

As early as 2006, the Kazakhstani government had introduced the "Concept for Transition to Sustainable Development", which was partially translated into legislation supporting the development of renewable energy.[24] Another important official document was the "Strategy Kazakhstan 2050" released in 2012 to propel Kazakhstan to the top 30 developed countries in the world by 2050. It included a strategic priority to raise renewable energy generation. The 2013 Green Economy Concept called for 50% of electricity to be generated from alternative or renewable sources, including nuclear, by 2050 (see Table 2). It also aimed by 2050 to

[16] Ministry of Energy of the Republic of Kazakhstan, *Seventh national communication and third biennial report of the republic of Kazakhstan to the UN framework on climate change* (Astana: Ministry of Energy, 2017), 27, https://unfccc.int/sites/default/files/resource/20963851_Kazakhstan-NC7-BR3-1-ENG_Saulet_Report_12-2017_ENG.pdf
[17] M. Poberezhskaya and A. Bychkova, "Kazakhstan's climate change policy: Reflecting national strength, green economy aspirations and international agenda," Post-Communist Economies 34, no. 7, (2022): 894-915, https://doi.org/10.1080/14631377.2021.1943916
[18] Office of the President of the Republic of Kazakhstan, *Concept for transition of the Republic of Kazakhstan to Green Economy*, May 30, 2013, https://igtipc.org/images/categories/green_concept_en.pdf
[19] Bjerde and Proskuryakova, "Climate Action Can Catalyze."
[20] Zhanna Shayakhmetova, "Kazakhstan Declares its Carbon Neutrality Targets at UN Climate Change Conference in Glasgow," *The Astana Times*, November 2, 2021, https://astanatimes.com/2021/11/kazakhstan-declares-its-carbon-neutrality-targets-at-un-climate-change-conference-in-glasgow/
[21] Poberezhskaya and Bychkova, "Kazakhstan's climate change policy."
[22] "President Kassym-Jomart Tokayev's State of the Nation Address 'Economic course of a Just Kazakhstan'," Official website of the President of the Republic of Kazakhstan, last modified September 1, 2023, https://www.akorda.kz/en/president-kassym-jomart-tokayevs-state-of-the-nation-address-economic-course-of-a-just-kazakhstan-283243
[23] The Paris Agreement was an international treaty adopted in 2015 by almost all nations to curb greenhouse gas emissions and limit global temperature rise to 2 degrees Celsius above pre-industrial levels, while pursuing the means to limit the increase to 1.5 degrees.
[24] Nikolai Mouraviev, "Renewable energy in Kazakhstan: Challenges to policy and governance," *Energy Policy* 149 (2021): 112051, https://doi.org/10.1016/j.enpol.2020.112051

lower energy intensity of GDP to 50% of 2008 levels and cut CO_2 emissions in power generation by 40%. By December 2020, President Tokayev announced that the country aimed to achieve carbon neutrality by 2060. The "Strategy for Achieving Carbon Neutrality by 2060" adopted in February 2023 further crystallised Kazakhstan's decarbonisation efforts.

Decarbonising the energy value chain would require the involvement and collaboration of several government organisations (see Table 3). Kazakhstan's energy transition would not come cheap. According to the Minister of Ecology, Geology, and Natural Resources Serikkali Brekeshev, US$650 billion of investments in low carbon technologies would be needed over 40 years to achieve the net-zero target. Of this, the electricity and thermal energy sector alone required US$305 billion.[25] Much of the investment would have to come from the private sector.

Table 1: GHG emissions targets for Kazakhstan

	1990	**2030**		**2060**
		Unconditional	Conditional	
Target ($MtCO_2e$)	386	328 (15% below 1990 level)	290 (25% below 1990 level)	Net-zero

Source: Zholdayakova et. al.[26]

Table 2: Energy-related targets under the Green Economy Concept

Sector	**Indicator**	**2020**	**2030**	**2050**
Energy efficiency	Reduction of energy intensity of GDP from levels of 2008	25%	30%	50%
Power sector	Share of alternative sources (solar, wind, hydro, nuclear) in electricity production	Excluding large-scale hydropower: not less than 3%	Overall: 30% Excluding large-scale hydropower: 10% (raised to 15% in 2021)	Overall: 50%
	Share of gas power plants in electricity production	20%	25%	30%
	Gasification of regions	Akmola and Karaganda regions	Northern and eastern regions	
	Reduction of current CO2 emissions in electricity production	Levels of 2012	-15%	-40%

Source: Office of the President of the Republic of Kazakhstan.[27]

Table 3: Key government organisations involved in Kazakhstan's energy sector

Organisation	**Role**
Ministry of Energy	Established in 2014 by consolidating the energy portfolio previously spread across three ministries; responsible for overall policymaking for the energy sector and has regulatory authority over oil and gas exploration and production, oil refining, gas processing, coal sector, and nuclear energy. The ministry also set up a Green Economy Council to promote the development of renewable energy.
Ministry of National Economy	The ministry's Committee for Regulation of Natural Monopolies and Protection of Competition (KREM) regulates electricity and gas networks as well as retail prices for power and gas.
Ministry of Ecology, Geology and Natural Resources	The ministry's Committee for Environmental Regulation and Control regulates the environmental impacts in the energy sector.

[25] "Kazakhstan needs investments worth $650bn to achieve its carbon neutrality target," *Kazakhstan Today*, October 27, 2021, https://www.kt.kz/eng/economy/kazakhstan_needs_investments_worth_650bn_to_achieve_its_1377923726.html
[26] S. Zholdayakova, Y. Abuov, D. Zhakupov, B. Suleimenova, and A. Kim, *Toward Hydrogen Economy in Kazakhstan*, ADBI Working Paper 1344 (Tokyo: Asian Development Bank Institute, 2022), https://doi.org/10.56506/IWLU3832
[27] President of the Republic of Kazakhstan, "Green Economy."

Ministry of Industry and Infrastructure Development	The ministry's Committee for Industrial Development oversees energy efficiency for industry, including key energy-consuming industries such as mining, metallurgy and chemicals.
Samruk-Kazyna JSC	Kazakhstan's sovereign wealth fund; owns and manages the state's holdings in several companies in the energy sector, including oil and gas firm, KazMunayGas (KMG); KMG's gas subsidiary, QazaqGaz; national electricity transmission grid operator, Kazakhstan Electricity Grid Operating Company (KEGOC); wholesale electricity market operator, Kazakhstan Electricity and Power Market Operator (KOREM); and power company, Samruk-Energy.

Source: Author's compilation.

Fossil Fuels Conundrum

The country's proven oil reserves of over 3.9 billion tonnes were ranked 12th largest globally, while its proven natural gas reserves of 2.3 trillion m^3 were among the 20 largest in the world in 2021.[28] The oil and gas sector accounted for about 17% of GDP in 2020, and is a major export earner – almost 60% of its domestic energy production was exported in 2020.[29] Its coal reserves, most of which are cheap to mine, are the world's tenth largest, and at current rates of production, would last more than 200 years.[30] Coal is also by far the worst CO_2 emitter (Figure 5 in Annex). Another more potent GHG, methane is also released by coal mining activities. In 2021, coal produced 58.6% of CO_2 emissions from fuel combustion, while oil and natural gas accounted for 22.5% and 18.9% respectively.[31]

While its share in the energy mix has fallen over the years, coal remains the backbone of Kazakhstan's energy sector, especially in electricity and heat generation. In 2022, it accounted for almost 46% of primary energy consumption which included all energy uses such as electricity, transport and heating; oil and gas each supplied about 25% (Figure 6 in Annex).[32] According to the International Energy Agency (IEA), the share of coal in Kazakhstan's energy supply was almost twice the world average, and the use of coal in the residential sector was one of the world's highest.[33] In line with Kazakhstan's climate goals however, the government's Doctrine of Carbon Neutral Development noted that the country would have to cut coal consumption substantially in the coming years, including decommissioning all coal power plants by 2050.[34]

On the other hand, natural gas saw the largest growth since the gas network was expanded,[35] such as the Beyneu-Bozoy-Shimkent pipeline which delivered gas from the west to settlements in the south that historically imported Uzbekistan gas. Gasification is also being extended to the previously unpiped north-central region as well as smaller cities and towns. The overall level of gasification almost doubled from 30% of the population in 2013[36] to 59% in 2022.[37] Kazakhstan also imports gas from Uzbekistan, Turkmenistan and Russia to help meet rising domestic demand, although Uzbekistan itself was forced to import gas from Russia to meet soaring demand in the winter of 2023.[38] Natural gas which is often seen as the cleanest fossil fuel,

[28] IEA, *Kazakhstan 2022*, 32.
[29] IEA, *Kazakhstan 2022*, 17-8.
[30] IEA, *Kazakhstan 2022*, 59.
[31] "Kazakhstan: Emissions," IEA, accessed April 11, 2024, https://www.iea.org/countries/kazakhstan/emissions#what-are-the-main-sources-of-co2-emissions-in-kazakhstan
[32] "Share of energy consumption by source, Kazakhstan," Our World in Data, accessed March 27, 2024, https://ourworldindata.org/grapher/share-energy-source-sub?country=~KAZ
[33] IEA, *Kazakhstan 2022*, 21, 59.
[34] "Доля ВИЭ к 2060 году достигнет более 80% от общего энергобаланса Казахстана – Президент," ["The share of RES by 2060 will reach more than 80% of the total energy balance of Kazakhstan – President,"] *Kazinform*, October 13, 2021, https://www.inform.kz/ru/dolya-vie-k-2060-godu-dostignet-bolee-80-ot-obschego-energobalansa-kazahstana-prezident_a3848568.
[35] Much of Kazakhstan's gas transportation system was historically geared towards the transit of gas from Uzbekistan and Turkmenistan to Russia and China.
[36] IEA, *Kazakhstan 2022*, 21, 47.
[37] Kazenergy Association, *National Energy Report 2023* (Astana: Kazenergy, 2023), 165.
[38] Catherine Putz, "Russian Gas Supplies to Uzbekistan Set to Grow," *The Diplomat*, March 7, 2024, https://thediplomat.com/2024/03/russian-gas-supplies-to-uzbekistan-set-to-grow/.

serves as an alternative to coal at least in the short term. Gas-fired power plants are also flexible enough to provide balancing capacity for the country's electricity system when other sources fall short.

Gas consumption, particularly for electricity and heat generation, more than tripled between 2000 and 2022.[39] In 2022, 55% of gas sold to consumers was used to produce electricity and heat,[40] while gas-fired power plants generated about 20% of electricity.[41] The Ministry of Energy planned to add another 1,800 km of gas networks in the country for 65% of the population (13.5 million) to have access to natural gas by 2030.[42] Another emerging market for natural gas is as a transport fuel. This has been supported by the government's plan to increase the number of filling stations for compressed natural gas (CNG) and liquified natural gas (LNG). The government also set a target for natural gas to make up at least 50% of public road transport's fuel consumption by 2030 in major population centres of Almaty, Astana and Shymkent, and at least 30% in other regional centres.[43]

However, despite the country's substantial gas reserves, the gas market struggled to meet domestic demand. Retail tariffs for natural gas are set by KREM based on region and customer type, while the Ministry of Energy and Ministry of National Economy set maximum wholesale prices for commercial gas in each region. While such price caps kept gas affordable for the public and businesses, it was often unprofitable for producers to sell gas to QazaqGaz, the national gas company which has the first right to buy gas from other domestic producers. Instead, it made more economic sense for producers to reinject the gas to boost oil production. QazaqGaz was also apparently cross-subsidising losses on domestic gas market with gas export sales and transit operations, primarily to China.[44] Low domestic gas prices also blunted the incentive for private sector to develop new gas production. Moreover, the core gas transportation infrastructure built during the Soviet era suffered from high rates of deterioration and was in dire need of modernisation.[45]

On the other hand, while the government is keen on gasification to cut emissions, natural gas may not be as clean as it has been made out to be. The global warming impact of methane, the main component of natural gas, which could be leaked during extraction, storage and burning, is far higher than that of CO_2. In fact, a major methane leak, described as possibly the "second worst man-made methane leak ever recorded", reportedly occurred in the country's Mangistau region over six months in 2023, releasing an estimated 127,000 tonnes of methane.[46]

Rising energy demand, especially in the residential sector, will make it harder for the government to provide enough palatable low-carbon energy options. Driven by a fastest-growing economy, population growth from 14.88 million in 2000 to 19.62 million 2022, and rising urbanisation, primary energy consumption per capita rose from 24,268 kWh in 2000 to 44,702 kWh in 2022.[47] The residential sector has overtaken the industrial sector to become the biggest energy consumer in Kazakhstan. In 2021, it accounted for 34% of final energy consumption, compared to the industrial sector's 30% (Figure 7 in Annex).[48] Given Kazakhstan's cold climate,

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[39] Kazenergy, *National Energy Report*, 171.
[40] Kazenergy, *National Energy Report*, 170
[41] Kazenergy, *National Energy Report*, 217.
[42] "In the oil industry at the end of 2021, oil production is expected to reach 85.7 million tons – Ministry of Energy," Official Information Source of the Prime Minister of the Republic of Kazakhstan, last modified December 22, 2021, https://primeminister.kz/en/news/v-neftyanoy-otrasli-po-itogam-2021-goda-obem-dobychi-nefti-ozhidaetsya-na-urovne-857-mln-tonn-minenergo-22111737
[43] IEA, *Kazakhstan 2022*, 48.
[44] IEA, *Kazakhstan 2022*, 48.
[45] Kazenergy, *National Energy Report*, 165.
[46] Marco Silva, Daniele Palumbo, and Erwan Rivault, "Kazakhstan: Methane mega-leak went on for months," *BBC News*, February 16, 2024, https://www.bbc.com/news/world-asia-68166298
[47] "Primary energy consumption per capita," Our World in Data, accessed March 27, 2024, https://ourworldindata.org/grapher/per-capita-energy-use?tab=chart&country=~KAZ
[48] "Kazakhstan: Energy mix," IEA, accessed April 11, 2024, https://www.iea.org/countries/kazakhstan/energy-mix#how-is-energy-used-in-kazakhstan

heating of space and water in the residential sector consumes significant energy. Between 2003 and 2021, the energy intensity of residential buildings rose by 2.5 times.[49] Cheap and easily available, the share of coal in residential energy consumption is one of the highest globally, although natural gas has increasingly replaced coal for heating, especially in urban areas. In 2021, natural gas and coal accounted for 28% and 26% respectively of residential energy use.[50] In the industrial sector, coal was the most common fuel consumed (33%) in 2020, especially in iron and steel and non-ferrous metal manufacturing.[51] The transport sector's energy consumption, mostly of gasoline, diesel and liquified petroleum gas (LPG), grew by almost 60% between 2010 and 2020.[52]

The current energy pricing framework has added to the energy transition challenge. The government has kept domestic energy prices such as gas tariffs low for years, although it has started to introduce some market mechanisms. One exception is coal prices for residential consumers which is unregulated. In some cases, the permitted retail price is set below production cost. For example, LPG reportedly cost around KZT80 per litre to produce in Kazakhstan, but the retail price was capped at KZT60 per litre until 2022.[53] Energy prices often touch a raw nerve among the public. When the government lifted price caps in January 2022 on LPG which is used as a fuel for cars, nationwide protests erupted, forcing the government to declare a state of emergency in some regions and temporarily backtrack on its policy.[54] Low prices in oil products also reportedly led to smuggling, particularly in diesel fuel, to neighbouring countries where prices are higher.[55]

There is also room to improve energy efficiency in Kazakhstan and thereby reduce GHG emissions. Energy efficiency policies and measures have been in place since the early 2000s. These included minimum energy performance standards for appliances and energy-using equipment and for buildings, fuel economy standards for the transport sector, as well as energy audit provisions for industry. However, implementation and enforcement of energy efficiency regulations has been patchy. For instance, the IEA pointed out that minimum energy performance standards for new buildings and retrofits were poorly enforced, energy efficiency standards for appliances and equipment were dependent on support from international donors, while tightening of fuel economy standards had been delayed and hampered by a lack of labelling requirements and incentives for consumers.[56]

For heating, rural households depend on less efficient individual heating systems running on coal or natural gas, while urban areas are hampered by outdated district heating systems and lack of metering. Moreover, such inefficient heating systems are a significant source of air pollution, particularly fine particulate matter like PM2.5[57] that threaten health. A World Bank study estimated that ambient air PM2.5 pollution cost US$10.5 billion (equivalent to 6.5% of GDP) in health damage and caused 10,133 deaths in Kazakhstan in 2019.[58]

Low energy prices have also shielded end-users from the real cost of energy and provide few incentives to adopt more energy-efficient equipment and practices. Developing a comprehensive energy efficiency policy framework in Kazakhstan, experts agreed, would require reforms to energy tariffs.[59]

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[49] "Kazakhstan: Efficiency and demand," IEA, accessed April 11, 2024, https://www.iea.org/countries/kazakhstan/efficiency-demand#how-does-the-residential-sector-in-kazakhstan-use-energy

[50] "Kazakhstan: Efficiency and demand."

[51] IEA, *Kazakhstan* 2022, 127.

[52] IEA, *Kazakhstan 2022*, 129.

[53] IEA, *Kazakhstan 2022*, 49.

[54] "Kazakhstan unrest: Government restores fuel price cap after bloodshed," *BBC*, January 6, 2022, https://www.bbc.com/news/world-asia-59896471

[55] IEA, *Kazakhstan 2022*, 31.

[56] IEA, *Kazakhstan 2022*, 130.

[57] PM2.5 refers to atmospheric particulate matter that have a diameter of less than 2.5 micrometres.

[58] World Bank, *The Global Health Cost of PM2.5 Air Pollution: A Case for Action Beyond 2021* (Washington, DC: World Bank, 2022), 31, 37, 43, doi:10.1596/978-1-4648-1816-5

[59] IEA, *Kazakhstan 2022*, 130.

With its energy transition in motion, how far could natural gas substitute for coal? And could the government afford to continue keeping a lid on energy prices?

Precarious Electricity Sector

Total electricity production in Kazakhstan more than doubled from 51.32 billion kWh in 2000 to 115.08 billion kWh in 2021.[60] By 2024, the country had a total available capacity of 20.4 GW, with an operating capacity of 15.4 GW.[61] Coal was even more dominant in the electricity sector, generating almost 60% of electricity production in 2021 (Figure 8 in Annex).[62] The northern region depended on coal-fired power plants, while the southern region imported coal-fired power from the north. Gas-fired power accounted for 28% of electricity production and operated mostly in the isolated and sparsely-populated oil- and gas-producing western region, which has a regional grid not connected to the north or south. Kazakhstan also relies on electricity imports and exports with its neighbours to smoothen out seasonal energy demands. Southern Kazakhstan is part of the Central Asian Power System (CAPS), a power grid interconnected with neighbouring Kyrgyzstan and Uzbekistan. Northern Kazakhstan is linked to the Russian grid.

Power generation was responsible for more than half (52%) of all energy-related CO_2 emissions in Kazakhstan in 2021, and coal was the biggest culprit, responsible for 77% of CO_2 emissions from power generation (Figure 9 in Annex).[63] Renewables currently play a minor role in electricity generation, and most of the country's hydropower and solar PV capacity are in the south. Among renewable energy sources, hydropower generated 8% of electricity production, while renewable sources excluding large-scale hydropower reached 4.4% in 2022.[64]

Kazakhstan's electricity market is already one of the most liberalised among Central Asian economies. Much of the electricity sector had been privatised, except for high-voltage transmission managed by KEGOC and electricity market operator KOREM. Wholesale electricity prices are not regulated and are determined by the market operated by KOREM. Nevertheless, the IEA assessed that Kazakhstan's retail electricity tariffs were one of the lowest in the world, supported indirectly by one of the highest rates of fossil fuel subsidy per capita at a cost of over 3% of GDP.[65]

Cutting the use of coal too fast could raise the likelihood of electricity shortages in the near term, especially when faced with growing electricity demand. The government has come under increasing pressure to ramp up electricity generation and ensure stability and reliability of the grid system. Between 2000 and 2021, electricity consumption per capita increased by about 70% from about 3 MWh to 5.53 MWh.[66] Industry has been the largest electricity consumer and growth in electricity demand is largely tied to increasing industrial output. For instance, power-hungry crypto mining which the government initially encouraged, was reportedly draining an astounding 7% of the country's generating capacity in 2021, until the government cut off their access to cheap electricity.[67]

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[60] "Kazakhstan: Electricity", IEA, accessed April 11, 2024, https://www.iea.org/countries/kazakhstan/electricity#where-does-kazakhstan-get-its-electricity

[61] "Ministry of Energy works out measures plan for electric power industry development; 26 GW of new generating capacities to be commissioned," Official Information Source of the Prime Minister of the Republic of Kazakhstan, January 16, 2024, https://primeminister.kz/en/news/ministry-of-energy-works-out-measures-plan-for-electric-power-industry-development-26-gw-of-new-generating-capacities-to-be-commissioned-26978

[62] "Kazakhstan: Electricity."

[63] "Kazakhstan: Electricity."

[64] Bureau of National Statistics, "Fuel and energy balance of the Republic of Kazakhstan (2022)," last modified August 1, 2023, https://stat.gov.kz/en/industries/business-statistics/stat-energy/publications/75978/

[65] IEA, *Kazakhstan 2022*, 130.

[66] "Kazakhstan: Electricity."

[67] Peter Guest, "Bitcoin mining was booming in Kazakhstan. Then it was gone," MIT Technology Review, January 12, 2023, https://www.technologyreview.com/2023/01/12/1066589/bitcoin-mining-boom-kazakhstan/

Power outages has roiled the country in recent years. For instance, in October 2021, three power plants in northeastern Kazakhstan were shut down in an emergency with a loss of over 1,000 MW of electricity. Rolling blackouts were reported in early November 2021 across some regions including areas around the cities of Almaty and Shymkent.[68] In January 2022, a major blackout left millions without power across swathes of southern Kazakhstan, Kyrgyzstan and Uzbekistan when a surge in demand on CAPS from Uzbekistan overloaded Kazakhstan's transmission system.[69] Another prolonged blackout during frigid conditions in northern Kazakhstan in November 2022 left thousands without heating and sparked widespread anger.[70]

Part of the reason for the power disruptions was the crumbling, inefficient and increasingly unreliable Soviet-era power infrastructure that the government had been struggling with for some time. Most of the country's main power generation plants were over 40 years old and showing their age, with the level of depreciation averaging 53%.[71] The main transmission grid owned and operated by majority state-owned KEGOC also experienced worsening system stability.[72] An Asian Development Board (ADB) report in 2016 highlighted that the country's power plants were operating at "only 60-70% the total capacity, due to a lack of investment towards rehabilitation and modernisation" and "70% of the power generation infrastructure (was) in need of rehabilitation".[73] Investments in existing and new power generating capacity had rolled in under a "tariff-for-investment" programme where electricity producers could apply for temporarily higher tariffs in return for investment commitments, but these had tapered off since 2015.[74] Nevertheless, a new "tariff-for-investment" programme was apparently in the works to attract investments of KZT400 billion to rehabilitate, modernise and expand the power sector.[75]

The Ministry of Energy forecast that Kazakhstan would have an electricity deficit of more than 6 GW by 2030.[76] The electricity sector also had to be decarbonised. To close the gap and increase potential electricity exports, the ministry announced an action plan in January 2024 to modernise existing power plants and commission 26 GW of new generating capacity by 2035.[77] The new installed capacity comprised renewables (24.4%), hydropower (10.8%), gas (25.8%), coal (34.3%) and – although the referendum had yet to take place – nuclear power (4.7%). The ministry expected the reduction in coal-fired power and expansion of gas-fired generation alongside more electricity from renewable or alternative energy sources to offset 44 Mt of CO_2 per year by 2035.

Were renewables and alternative energy up to the task?

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

[69] Paul Barlett, "Central Asia's struggle to keep lights on fuels nuclear ambitions," *Nikkei Asia*, February 5, 2022, https://asia.nikkei.com/Politics/International-relations/Central-Asia-s-struggle-to-keep-lights-on-fuels-nuclear-ambitions

[70] "Power cuts in -30C spark anger in Kazakhstan," *France24*, December 10, 2022. https://www.france24.com/en/live-news/20221210-power-cuts-in-30c-spark-anger-in-kazakhstan

[71] IEA, *Kazakhstan 2022*, 73.

[72] IEA, *Kazakhstan 2022*, 79.

[73] PwC, *CAREC: Study for Power Sector Financing Road Map; Mobilizing Financing Priority Projects – Kazakhstan* (ADB TA 8727 REG), September 2016, https://www.carecprogram.org/uploads/CAREC_TA8727_CountryReport_Kazakhstan.pdf

[74] IEA, *Kazakhstan 2022*, 73.

[75] "New 'Tariff for Investment' programme aims to attract up to 400 billion tenge of investment into industry annually," Official Information Source of the Prime Minister of the Republic of Kazakhstan, December 20, 2022, https://primeminister.kz/en/news/new-tariff-for-investment-programme-aims-to-attract-up-to-400-billion-tenge-of-investment-into-industry-annually-2211150

[76] "Ministry of Energy works out measures plan for electric power industry development; 26 GW of new generating capacities to be commissioned," Official Information Source of the Prime Minister of the Republic of Kazakhstan, January 16, 2024, https://primeminister.kz/en/news/ministry-of-energy-works-out-measures-plan-for-electric-power-industry-development-26-gw-of-new-generating-capacities-to-be-commissioned-26978

[77] "Ministry of Energy works out measures plan," Prime Minister of the Republic of Kazakhstan.

Renewables Growth Hampered

Kazakhstan has tapped hydropower for many years through its hydropower plants located largely in the eastern and southeastern regions of the country. Of the estimated 170 billion kWh per year potential of hydropower resources, about 62 billion kWh per year was considered technically feasible.[78] The share of renewables, primarily large-scale hydropower (more than 35 MW), in electricity generation hit a high of 15% in 2002, but had since declined to about 8%.[79] The country's large hydropower generating capacity stood at 1.6 GW in 2019.[80]

However, the ecological and social impacts of large-scale hydropower were controversial. Hydropower also had to compete with other major water uses such as irrigation for agriculture. Water resources under pressure from climate change could also become less reliable. Water resources are further complicated by Kazakhstan's downstream dependency on transboundary river flows from neighbouring countries like Uzbekistan, Kyrgyzstan, Russia and China, who are increasing their rates of water extraction. Relatively low tariffs for hydropower-generated electricity, which are capped at the rates of previous auctions, had also made hydropower projects less attractive to investors. Of the hydropower projects auctioned between 2018 and 2020, only a few were being implemented.[81]

Nonetheless, among renewable energy sources, hydropower had been given "special emphasis" by the government.[82] The government would continue developing new large hydropower plants including inter-territorial projects such as the 1,860-MW hydropower plant at Kambar-Ata Dam in Kyrgyzstan. On the other hand, as a Ministry of Energy official pointed out, Kazakhstan has numerous small rivers, making small hydropower plants ideal.[83] Moreover, such small hydropower plants could serve as flexible capacity to help keep Kazakhstan's electricity system in balance.

Thanks to its massive plains and natural wind corridors, Kazakhstan is arguably Central Asia's most well-endowed in renewable energy sources in terms of both diversity and scale. It has what an ADB report called "extraordinary wind power potential".[84] With favourable wind speeds of about 5 m/s required to operate wind turbines, Kazakhstan's potential wind power was estimated at a staggering 920 billion kWh per year, far exceeding the country's total electricity currently generated.[85] Its solar power potential was smaller, but still sizeable, at an estimated 2.5 billion kWh per year,[86] making concentrated solar thermal and solar photovoltaic (PV) power generation both technically and economically feasible.

Biomass was another underutilised source of renewable energy – only three biogas facilities with a combined capacity of 1.77 MW had been set up so far.[87] The large quantities of agricultural waste from crops and livestock could be used to fuel biogas production, while municipal solid waste currently channelled to landfills could instead be directed to waste-to-energy plants built near larger cities. While the country has geothermal resources, these have yet to be studied in detail.

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[78] IEA, *Kazakhstan 2022*, 90.
[79] Elena Shadrina, *Renewable energy in Central Asian economies: role in reducing regional energy insecurity*, ADBI Working Paper Series No. 993 (Tokyo: Asian Development Bank Institute, 2019), https://www.adb.org/publications/renewable-energy-central-asian-economies
[80] IEA, *Kazakhstan 2022*, 89.
[81] Saniya Perzadayeva and Nurmolda Ospangali, "Kazakhstan: Barriers to the Implementation of Hydropower Projects in Kazakhstan," 31 January 2022, *Mondaq*, https://www.mondaq.com/renewables/1155356/barriers-to-the-implementation-of-hydropower-projects-in-kazakhstan
[82] "Economic course of a Just Kazakhstan," Official website of the President of the Republic of Kazakhstan.
[83] Zhanbolat Mamyshev, "Energy ministry wants to build more hydropower plants in Kazakhstan," *Kursiv*, September 20, 2023, https://kz.kursiv.media/en/2023-09-20/energy-ministry-wants-to-build-more-water-power-plants-in-kazakhstan/
[84] Shadrina, *Renewable energy in Central Asian economies*.
[85] IEA, *Kazakhstan 2022*, 89.
[86] IEA, *Kazakhstan 2022*, 90.
[87] "Kazakhstan's Renewable Energy Sector Gains Momentum with 146 Facilities in Operation," *The Astana Times*, March 5, 2024, https://astanatimes.com/2024/03/kazakhstans-renewable-energy-sector-gains-momentum-with-146-facilities-in-operation/

Kazakhstan had a relatively early start in developing renewables with the introduction of the 2009 Law About Support of Use of Renewable Energy Sources. This established the legal framework for renewable energy production, including issuance of permits for new projects and regulation of prices to ensure that renewables were cost-comparable to fossil fuels. The Financial Settlement Centre (FSC), a subsidiary of KEGOC, was also established to serve as the guaranteed single buyer and seller of electricity generated from renewable energy. As the main grid operator, KEGOC is required to connect all renewable energy producers with power purchase agreements with the FSC and prioritise them in dispatching. Renewable energy investments also enjoyed tax benefits, exemptions from VAT and custom duties as well as in-kind grants including grants for land, buildings or equipment. To ease the financial strain on domestic conventional power producers who pay for the electricity produced from renewables, the government allowed the cost of renewables to be passed through to end-users as an added tariff in 2020.

To ramp up investments in renewables, the government introduced a feed-in tariff (FiT) programme in 2014 for renewable energy utilities, including wind, solar, biomass, geothermal and smaller-scale hydropower (up to 35 MW). Under the FiT programme, renewable energy power plants were given guaranteed power prices for 15 years from 2013 to 2028 (Table 4). The FSC was obliged to buy all the electricity produced by renewable energy producers with whom it had power purchase agreements. However FiT was replaced with auctions in 2018 due to its ineffectiveness.

The years after the government adopted the 2009 renewables law proved to be a steep learning curve. There were "a large number of problems and gaps in governance" in the renewables sector, including overlapping responsibilities, insufficient accountability and high degree of discretion among various government organisations; increasing risk of corruption; and lack of incentives to agencies responsible for developing renewable energy infrastructure and power generation facilities.[88] Moreover the case for renewables was far from clear throughout the country, especially for local and regional authorities who were unconvinced about the benefits of renewable energy for the local and regional economies vis-à-vis cheaper conventional power.[89] Approvals for renewables projects were delayed as regional officials "were really afraid of making any decision, perhaps because of the risk of being penalised", creating uncertainty for the private sector.[90] The FSC also suffered from a lack of credibility in its ability to pay, at least during its early years. This was partially addressed in 2020 through amendments to the renewables law which allowed the government to provide financial assistance to the FSC if it was unable to meet payment obligations to renewable energy project developers.

In the meantime, investors became increasingly frustrated by the confusion and delays in the bureaucratic approval processes; uncertainty about payments to renewable energy producers; and lack of access to long-term financing. For instance, a 2017 UNDP study estimated that the cost of equity for utility-scale wind energy and solar PV in Kazakhstan was 16% (USD), compared with 7% in Germany.[91] These hurdles in Kazakhstan turned away what some estimated to be "a few hundred" potential investors between 2010 and 2018.[92] The price differential between renewable and conventional energy also remained high. For instance, the average cost of one kWh generated at a coal-fired facility in 2017 was KZT7–8, compared to KZT22 at a wind farm, and KZT34 at a solar PV facility.[93]

[88] Mouraviev, "Renewable energy in Kazakhstan."
[89] Mouraviev, "Renewable energy in Kazakhstan."
[90] Mouraviev, "Renewable energy in Kazakhstan."
[91] UNDP, "Kazakhstan: Derisking Renewable Energy Investment; Key Points for Decision-Makers," June 2018, https://www.undp.org/energy/publications/drei-kazakhstan
[92] Mouraviev, "Renewable energy in Kazakhstan".
[93] Shadrina, *Renewable energy in Central Asian economies*, 23.

From 2018 onwards, the renewables sector transitioned from FiT to an auction system to determine tariffs for renewable energy projects. The size of new renewable energy capacity to be auctioned each year was set by the Ministry of Energy, which aimed to develop about 250 MW of renewable energy supply annually. Auctions were conducted by KOREM on behalf of the FSC. The validity of auction-determined tariffs was also extended from 15 to 20 years in December 2020. The auctions, which attracted international interest, were a way for the government to select the lowest-cost renewable energy projects and hence lower the price of renewables relative to conventional power. Tariffs under the auction system were indexed to Kazakhstan's consumer price index and exchange rates. Hedging against changes in the exchange rate was particularly important for renewable energy projects in Kazakhstan, as most equipment had to be imported and project loans were often denominated in foreign currencies. The auction system saw tariffs for solar, wind and hydropower fall, with solar power experiencing the sharpest drop (Table 4).

Table 4: Comparison of FiT and auction prices

Tariff (KZT/kWh)	Wind	Solar	Small hydropower	Biomass
Feed-in tariff (2013)	22.68*	34.61^	16.71	32.23
Minimum auction price (2021)	14.08	12.87	15.00	32.14

Source: IEA, "The Law"[94]; IEA, "Kazakhstan 2022".[95]

* Excluding 100 MW wind power plant Astana EXPO-2017's tariff of KZT 59.7 per kWh.

^ Excluding Kaz PV.

Some have been surprised by the pace of policy development for renewables. The government was "surprisingly very quick" to adopt laws and regulations to support the development of renewables; others applauded this as "a very smart move" by the government to cut the country's economic dependence on oil.[96] A UNDP nationwide survey in February 2023 showed that more than 90% of the public supported the government's transition to renewable energy sources.[97] Still, given the country's large fossil fuels sector, there was scepticism about the government's ambitious plans. Although Kazakhstan achieved its short-term target of generating 3% of electricity from renewables by 2020, most Kazakhstani policymakers and experts interviewed for a study predicted that the country would miss its renewables targets for 2030 and 2050.[98]

Another hurdle that could curtail the expansion of renewables is the lack of flexible generating capacity, which makes integrating more renewable energy capacity into the electricity system difficult. Given the intermittent and variable nature of renewables (e.g. insufficient solar radiation on cloudy or rainy days), Kazakhstan needs more flexible power-generating capacity that can be powered up or down to compensate accordingly. Kazakhstan still relies largely on the Russian power grid to cover its imbalances and maintain grid stability. However, the government has started in December 2021 to trial the use of auctions to attract investments to develop new flexible capacity, such as gas-fired and hydropower projects. Another solution that the government was considering was to make the inclusion of electricity storage such as batteries mandatory in renewable energy projects. One such project involved French renewables firm, TotalEnergies developing a 1 GW onshore wind farm combined with a 600 MWh battery energy storage system in the Zhambyl region.[99] Under the current power purchase agreements, renewable energy producers are paid only for what they actually produce and bear no liability for shortfalls, and hence they have little incentive to include storage. On the other hand, requiring storage to be incorporated would increase costs significantly for

[94] "The Law About Support the Use of Renewable Energy Sources (amended)," IEA, last modified January 24, 2022, https://www.iea.org/policies/5407-the-law-about-support-the-use-of-renewable-energy-sources-amended

[95] IEA, *Kazakhstan 2022*, 97.

[96] Mouraviev, "Renewable energy in Kazakhstan."

[97] Assel Satubaldina, "Kazakhstan Powers Ahead, Unleashing Potential of Renewable Energy Under Critical Challenges," *The Astana Times*, June 2, 2023, https://astanatimes.com/2023/06/kazakhstan-powers-ahead-unleashing-potential-of-renewable-energy-under-critical-challenges/

[98] Poberezhskaya and Bychkova, "Kazakhstan's climate change policy."

[99] "Kazakhstan: TotalEnergies signs a 25-year PPA for a 1 GW Wind Project," TotalEnergies, September 6, 2023, https://totalenergies.com/media/news/press-releases/kazakhstan-totalenergies-signs-25-year-ppa-1-gw-wind-project

renewable energy producers, and raise the sensitive question of whether the additional costs should be passed to end-users.

Still, the government was making headway in capitalising on the country's renewable energy. According to then Minister of Energy Nurlan Nogayev in 2021, the installed capacity of renewable energy facilities (excluding large-scale hydropower) had risen almost ten-fold from 178 MW in 2014 to 1,635 MW in 2020, and was expected to generate 6% of electricity by 2025.[100] By March 2024, the Ministry of Energy announced that there were 146 operational renewable energy facilities (solar, wind, smaller-scale hydropower and biomass) in the country with a total installed capacity of 2,900 MW, generating 5.9% of total electricity production in 2023.[101] This put Kazakhstan close to reaching its target of 6% by 2025. However although the deployment of solar and wind power had picked up considerably in recent years, each still only contributed between 1% to 2% of electricity generation. Most of Kazakhstan's vast renewables potential remained untapped.

Other powers in the region have also been eyeing Kazakhstan's renewables potential. Under a bilateral investment cooperation initiative, Chinese investments in solar and wind power projects in Kazakhstan saw an uptick since 2018.[102] For example, the 100 MW Zhanatas wind project in the Zhambyl region which is majority owned and developed by a Chinese state-owned corporation, started operation in June 2021 and has reportedly generated 750 million kWh of electricity by the end of 2022.[103] In December 2023, Kazakhstan inked a deal with UAE's state-owned renewables company, Masdar to build a 1 GW wind power project.[104] Kazakhstan and Saudi Arabia have also agreed on an energy partnership, including renewables and clean hydrogen.[105]

Could solar and wind energy production be ramped up quickly enough to displace coal, or would Kazakhstan have to double down on large-scale hydropower projects or other alternative fuels like nuclear power?

100 MW Zhanatas wind power plant.
Credit: Chinese Ministry of Commerce via CGTN.

[100] Ministry of Energy of the Republic of Kazakhstan, "The share of renewable energy in Kazakhstan will reach 6% by 2025," February 9, 2021, https://www.gov.kz/memleket/entities/energo/press/news/details/157790?lang=en
[101] "Kazakhstan's renewable energy generation reaches 5.92%", *QazaqGreen*, March 28, 2024, https://qazaqgreen.com/en/news/kazakhstan/1868/
[102] Yunis Sharifli, "China Adapts to Central Asia's Renewable Energy Landscape," Carnegie Endowment for International Peace, April 19, 2024, https://carnegieendowment.org/2024/04/19/green-new-wave-how-china-adapts-to-central-asia-s-renewable-energy-landscape-pub-92247
[103] "Feature: Chinese-funded wind farm injects vitality into Kazakh town," *Xinhuanet*, May 12, 2023, https://english.news.cn/20230512/7f14a2860cc74899b0376fb0a5b12c25/c.html
[104] Pramod Kumar, "Masdar strikes project deals in Angola and Kazakhstan," *Arabian Gulf Business Insight*, December 3, 2023, https://www.agbi.com/renewable-energy/2023/12/cop-28-masdar-angola-kazakhstan/
[105] "Saudi Arabia collaborates with Kazakhstan to improve energy partnership," *Arab News*, June 13, 2023, https://www.arabnews.com/node/2320786/business-economy

The Nuclear Option

While Ulken was picked as the site for the nuclear power plant in May 2022, nuclear energy had been on the government's agenda for over two decades.[106] In 2018, Kazakhstan Nuclear Power Plant (KNPP) company, a subsidiary of sovereign wealth fund Samruk Kazyna, began preparing a feasibility study on the need for nuclear power and the selection of its location. In his State of the Nation Address in September 2021, President Tokayev indicated that the government and Samruk-Kazyna "should explore the possibility of developing safe and environmentally friendly nuclear energy in Kazakhstan".[107] By 2023, President Tokayev announced that a national referendum would be called to decide on whether to develop nuclear energy after noting "different opinions" within Kazakhstan on the issue.[108]

Nuclear energy generated about 10% of electricity globally in 2020 and was the second-largest source of low emissions electricity after hydropower, exceeding the total combined contribution of wind and solar PV.[109] According to the IEA, nuclear power made "a major contribution" to climate change mitigation by avoiding about 66 Gt of CO_2 globally between 1971 and 2020; electricity generation emissions would have been almost 20% higher, if not for nuclear power.[110] A report from the United Nations Economic Commission for Europe warned that international climate goals would not be met without nuclear technologies.[111] China and Russia were steadily building up their portfolios in nuclear energy, while others were introducing nuclear power for the first time. Among advanced economies however, there had been a slowdown in investments in nuclear power for various reasons such as high costs, long construction times, as well as public opposition following the 2011 accident at Japan's Fukushima Daiichi Nuclear Power Station.[112] Some countries like Germany, Belgium and Spain were phasing out their nuclear power plants. Nonetheless, the growing number of countries making net-zero pledges was reviving interest in nuclear energy.

Kazakhstan already had assured access to uranium, the raw material widely used as nuclear fuel. It possessed 12% of the world's uranium deposits, which could be extracted at low cost.[113] Kazakhstan became the world's largest producer of natural uranium in 2009, and by 2022, it produced 43% of the world's uranium supply. For Kazakhstan, nuclear energy could replace coal to provide a reliable low-emissions source of baseload electricity, unlike more intermittent renewable energy sources such as solar and wind power. The proposed nuclear power plant at Ulken alone was expected to plug a 12% gap in Kazakhstan's electricity needs by 2035.[114] It was also seen as an opportunity to upskill the Kazakh workforce. The CEO of KNPP was bullish about the spillover benefits in terms of developing human resources – the proposed nuclear power plant would create up to 8,000 new jobs during construction and require 2,000 high-quality personnel for its

[106] Kazakhstan had a Soviet-era nuclear power plant at Aktau which was shut down in 1999.
[107] "State of the Nation Address by President of the Republic of Kazakhstan Kassym-Jomart Tokayev," Official website of the President of the Republic of Kazakhstan, September 1, 2021, https://www.akorda.kz/en/state-of-the-nation-addressby-president-of-the-republic-of-kazakhstan-kassym-jomart-tokayev-38126
[108] "Economic course of a Just Kazakhstan," Official website of the President of the Republic of Kazakhstan.
[109] IEA, *Nuclear Power and Secure Energy Transitions* (Paris: IEA, 2022), https://www.iea.org/reports/nuclear-power-and-secure-energy-transitions
[110] IEA, *Nuclear Power and Secure Energy Transitions*.
[111] "International climate objectives will not be met if nuclear power is excluded, according to UNECE report," UNECE, last modified August 11, 2021, https://unece.org/climate-change/press/international-climate-objectives-will-not-be-met-if-nuclear-power-excluded
[112] In March 2011, an earthquake in Japan triggered a tsunami which knocked out back-up generators at the Fukushima Daiichi nuclear power plant and caused cooling systems to fail. This led to a partial melt down in three reactors and the release of radioactive material. More than 100,000 people were evacuated around the plant. It was considered the second worst nuclear accident after the Chernobyl disaster in 1986.
[113] "Uranium and Nuclear Power in Kazakhstan," World Nuclear Association, last modified March 2024, https://world-nuclear.org/information-library/country-profiles/countries-g-n/kazakhstan.aspx
[114] Institute for the Study of Diplomacy, "The past and present of Kazakhstan's nuclear security – and why it matters to U.S. interests," Medium, September 6, 2023, https://medium.com/the-diplomatic-pouch/analysis-the-past-and-present-of-kazakhstans-nuclear-security-and-why-it-matters-to-u-s-420c752dfc12

operation.[115] President Tokayev put it more starkly – without nuclear power, Kazakhstan would "lose the entire economy, not to mention investments, and lose regional leadership".[116]

Among the public, the painful legacy of hundreds of Soviet nuclear tests conducted in Kazakhstan in the past made many wary of any talk about nuclear activities, even if it was the "peaceful atom". Nuclear waste was hazardous and long-lasting, and worse, nuclear plant accidents could be catastrophic as the episode in Fukushima demonstrated. The spate of incidents with Kazakhstan's power infrastructure which caused blackouts and power cuts failed to reassure many that a nuclear power plant would be properly run and maintained. Others also questioned the safety of building a nuclear power plant in a seismically active region.

The potential environmental impact was another major concern. Nuclear power plants need large quantities of water for cooling, which could affect the environment and exacerbate water scarcity in areas such as Lake Balkhash that were already under stress. As one of the largest lakes in Central Asia, it is a major ecological regulator and source of drinking water for the region. An estimated 20% of the country's population live within the lake basin, including some 2.2 million in Almaty. Economic development of the Xinjiang region in China was already diverting water from Ili River which fed Lake Balkhash.[117] Already under threat as the climate becomes hotter, water withdrawal for the nuclear power plant compounded by potential pollution from the plant would further threaten the lake and its ecosystem. Experts were concerned that building a nuclear power plant on the shores of the lake would "simply hasten the death of Balkhash".[118] While the construction of a nuclear power plant would bring economic development and jobs to places like Ulken, some residents also worried about the impact on the local fishing industry which was their livelihood.

What if supporting Kazakhstan's energy transition through nuclear energy, worsened water shortages?

Spurring the Hydrogen Economy

Kazakhstan could leverage its renewable energy sources to jumpstart its foray into the emerging hydrogen economy, particularly green hydrogen. Hydrogen is a clean fuel that when combined with oxygen in a fuel cell, produces electricity and heat with water vapour as a by-product. It can also be used directly or replace hydrocarbons in some industrial processes such as steelmaking. While traditional methods produced hydrogen with resulting CO_2 emissions, green hydrogen is a relatively new technology involving electrolysis which uses electricity from renewable sources to split hydrogen molecules from oxygen molecules in water without creating CO_2 emissions. Clean hydrogen,[119] produced with very low or no emissions, had the potential to decarbonise a range of industries, especially large emitters and hard-to-abate industries like long-haul transport, chemicals, and iron and steel. Equally important was the potential of hydrogen to serve as energy storage to help balance and integrate electricity generated from renewables into the electricity system. The World Economic Forum's Accelerating Clean Hydrogen Initiative called clean hydrogen "a critical success factor" for the transition to net-zero.[120] Consulting firm McKinsey predicted that clean hydrogen could help to avoid 20% of annual global emissions by 2050.[121]

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[115] Assel Satubaldina, "Nuclear Power Plant in Kazakhstan: What's Next," *The Astana Times*, August 18, 2023, https://astanatimes.com/2023/08/nuclear-power-plant-in-kazakhstan-whats-next/
[116] Satubaldina, "Nuclear Power Plant in Kazakhstan".
[117] Haley Nelson, "Kazakhstan's New Nuclear Problem: Lake Balkhash," Caspian Policy Centre, Feb 22, 2024 https://www.caspianpolicy.org/research/kazakhstan/kazakhstans-new-nuclear-problem-lake-balkhash
[118] Satubaldina, "Nuclear Power Plant in Kazakhstan."
[119] Clean hydrogen refers to green hydrogen and blue hydrogen; the latter is produced using methane in conjunction with carbon capture and storage.
[120] "Accelerating Clean Hydrogen Initiative," WEF, accessed April 15, 2024, https://initiatives.weforum.org/accelerating-clean-hydrogen-initiative/home
[121] "What is hydrogen energy?," McKinsey & Company, last modified September 27, 2023, https://www.mckinsey.com/featured-insights/mckinsey-explainers/what-is-hydrogen-energy

The game-changing decarbonisation potential of green hydrogen was not lost on the Kazakhstani government. Economies with access to abundant low-cost renewable resources would make the most attractive production locations for green hydrogen. Based on estimates from consulting firm PwC, the cost of producing clean hydrogen in Kazakhstan would drop from €5.50–5.75 per kg in 2020 to €3.00–3 .25 per kg in 2030 and €1.75–2.00 per kg in 2040, far lower than in Europe.[122] The government had identified hydrogen energy as a priority and state-owned oil and gas company, KMG had set up a Competence Center for Hydrogen Energy in April 2022 to conduct research on hydrogen energy technologies. Kazakhstan was also testing the waters through various international partnerships. For instance, in 2021, national investment agency Kazakh Invest signed a memorandum of understanding with Svevind Energy, a German company, to install wind and solar PV capacity to feed 30 GW of electrolysers producing green hydrogen and green ammonia in the Mangystau Region from 2031 onwards.[123] KMG also signed an agreement in 2021 with Linde, a German industrial gas company, to study the feasibility of producing green and blue hydrogen and ammonia.[124]

In April 2024, the government released a draft strategy for hydrogen energy development with a 2040 target of 10 GW of electrolysis capacity integrated with 10 GW of new dedicated renewable energy capacity.[125] It envisaged Kazakhstan becoming an exporter of clean hydrogen, while stimulating hydrogen use domestically in industry and heavy-duty transport such as buses and trucks, and rail. It also proposed the development of a gas-hydrogen fuel for the power sector. The strategy included hydrogen regulation, tax breaks, research and development grants, and a voluntary carbon market to encourage growth in the emerging hydrogen sector.

However, green hydrogen is still an emerging technology and costly, although McKinsey predicted that the cost of producing green hydrogen would halve by 2030.[126] Instead, the government appeared to be eyeing the export potential of clean hydrogen, while domestic industries would take time to adapt to using clean hydrogen. Another consideration was the need to develop transportation and storage infrastructure for hydrogen to connect production and demand centres, such as potentially using Kazakhstan's existing gas pipeline networks.

Tough Choices

The government would increasingly have to grapple with trade-offs across different policy objectives in Kazakhstan's energy transition. Hydrocarbons were deeply entrenched in the economy and energy sector, and even with decarbonisation, they would continue to play a major role for some time. Past neglect of the energy infrastructure, especially in the electricity sector, was taking a toll on the country's energy security just as demand was rising. Kazakhstan had made headway in capitalising on its enviable renewables potential by attracting investments – more would have to be done faster to ramp up renewables on a wider scale. It would also have to find ways to accommodate the variable nature of weather-dependent renewables like wind and solar PV. Alternative low-carbon energy sources like nuclear power and green hydrogen while promising, came with their own challenges. The government would also have to convince a jittery public that the benefits of nuclear energy outweighed its perceived drawbacks. How would Kazakhstan overcome its energy transition challenges?

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[122] "Quantifying the opportunity in green hydrogen," PwC, accessed April 15, 2024, https://www.pwc.com/gx/en/industries/energy-utilities-resources/future-energy/green-hydrogen-cost.html

[123] Bernd Radowitz, "'Extra-large scale in endless steppes': roadmap sees 30GW Kazakh green H2 vision built this decade," *Recharge*, 13 October 2021, https://www.rechargenews.com/energy-transition/extra-large-scale-in-endless-steppes-roadmap-sees-30gw-kazakh-green-h2-vision-built-this-decade/2-1-1081434

[124] Joseph Murphy, "Linde to study hydrogen, ammonia production in Kazakhstan," *Natural Gas World*, November 3, 2021, https://www.naturalgasworld.com/linde-signs-up-for-kazakh-hydrogen-ammonia-projects-93564

[125] Rachel Parkes, "New draft hydrogen strategy; Kazakhstan targets 10GW of electrolysers by 2040 but promises 'technological neutrality'," *Hydrogen Insight*, April 24, 2024, https://www.hydrogeninsight.com/policy/new-draft-hydrogen-strategy-kazakhstan-targets-10gw-of-electrolysers-by-2040-but-promises-technological-neutrality/2-1-1633304

[126] "What is hydrogen energy?"

Discussion Questions

1. What are the main challenges that Kazakhstan faces in transitioning to a sustainable energy system?

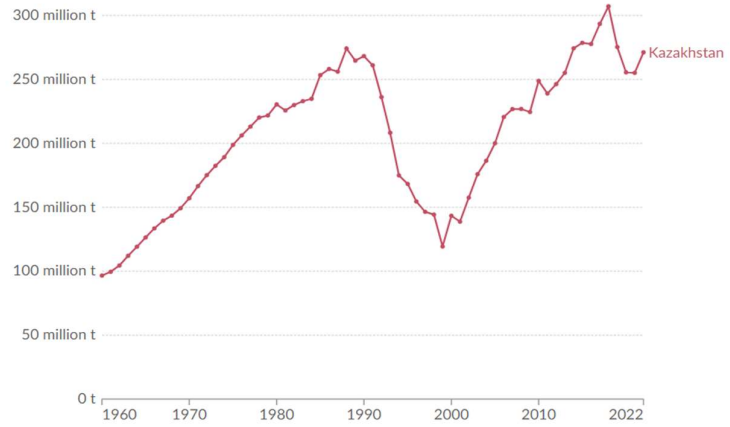
2. What economic and environmental trade-offs should be considered in the decision to build the Ulken nuclear power plant?

3. How do Kazakhstan's international commitments under the Paris Climate Agreement influence its national energy policies?

4. What strategic policy recommendations would you propose for Kazakhstan's energy transition?

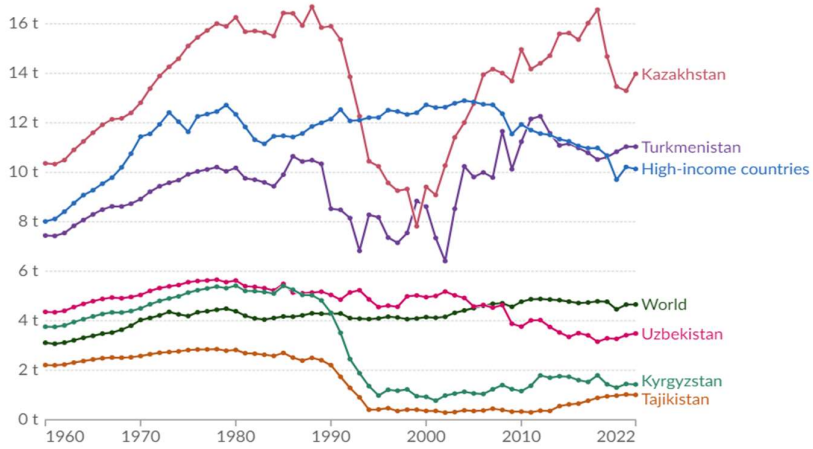
Annex

Figure 1: CO_2 emissions from fossil fuels and industry in Kazakhstan, 1960-2022



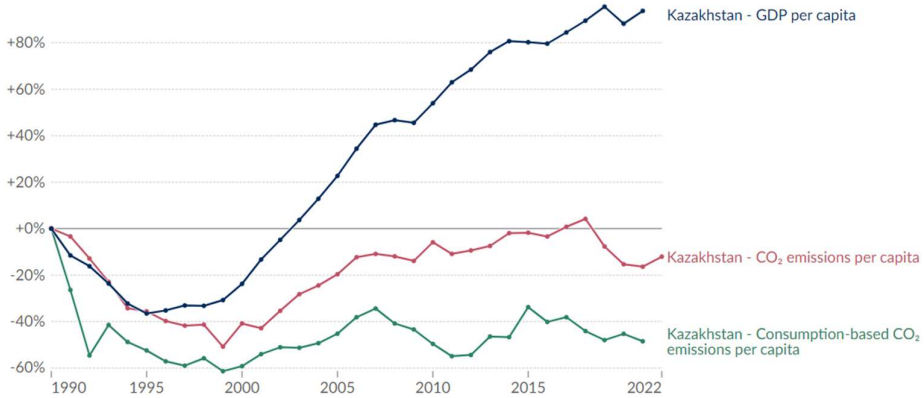
Source: Global Carbon Budget (2023), https://ourworldindata.org/co2-and-greenhouse-gas-emissions

Figure 2: Per capita CO_2 emissions from fossil fuels and industry in Kazakhstan and selected territories, 1960-2022



Source: Global Carbon Budget (2023); Population based on various sources (2023), https://ourworldindata.org/co2-and-greenhouse-gas-emissions

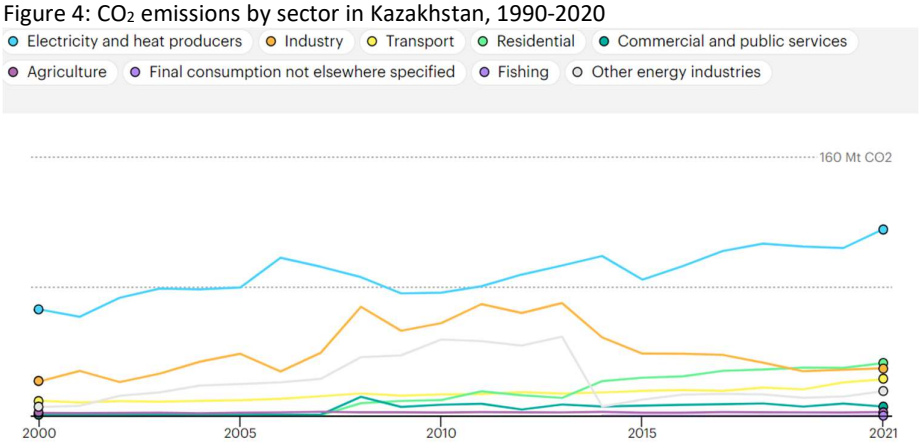
Figure 3: Change in per capita CO_2 emissions and GDP (excluding land-use change emissions) in Kazakhstan, 1990-2022



Source: World Bank (2023); Global Carbon Budget (2023); Population based on various sources (2023), https://ourworldindata.org/grapher/co2-emissions-and-gdp-per-capita?tab=chart&country=~KAZ

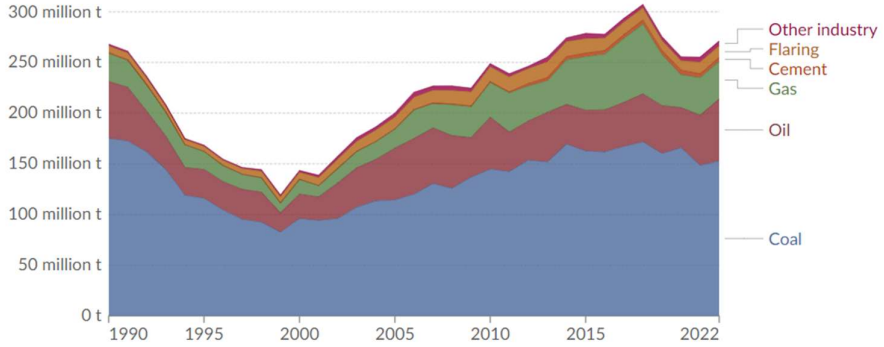
Notes: GDP figures are adjusted for inflation. Consumption-based emissions are national or regional emissions adjusted for trade.

Figure 4: CO_2 emissions by sector in Kazakhstan, 1990-2020



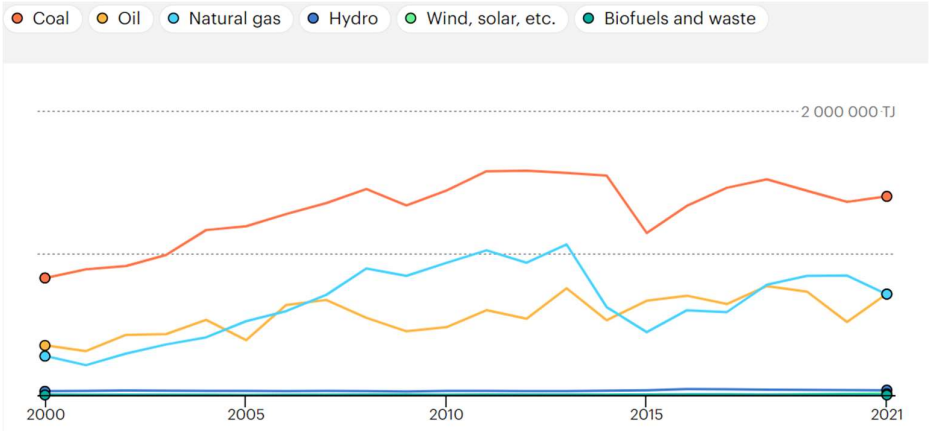
Source: IEA, https://www.iea.org/countries/kazakhstan/emissions#what-are-the-main-sources-of-co2-emissions-in-kazakhstan

Figure 5: CO_2 emissions by fuel or industry type in Kazakhstan, 1990-2022



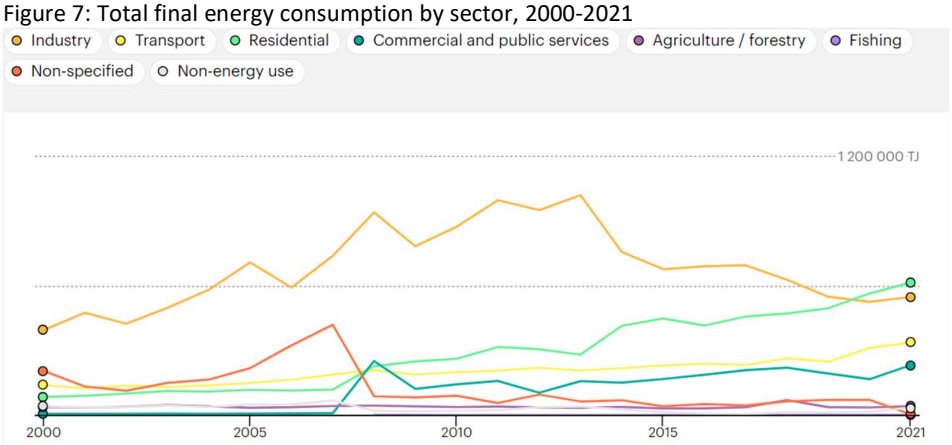
Source: Global Carbon Budget (2023), https://ourworldindata.org/grapher/co2-by-source?tab=chart&country=~KAZ

Figure 6: Total energy supply in Kazakhstan, 2000-2021



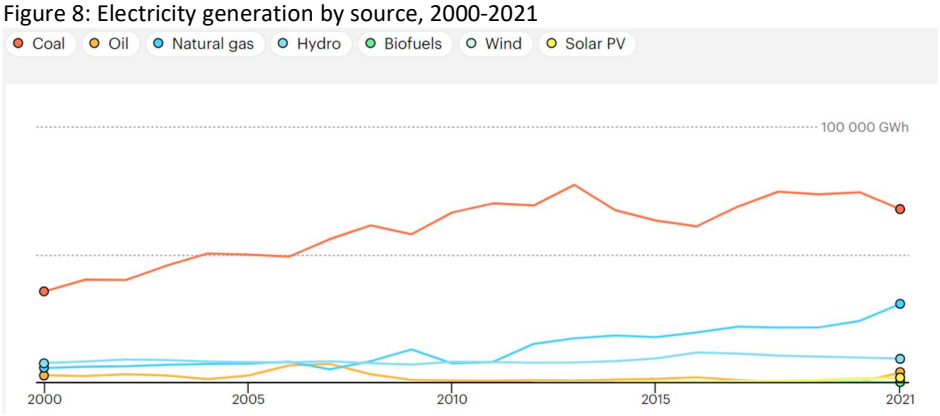
Source: IEA, https://www.iea.org/countries/kazakhstan/energy-mix

Figure 7: Total final energy consumption by sector, 2000-2021



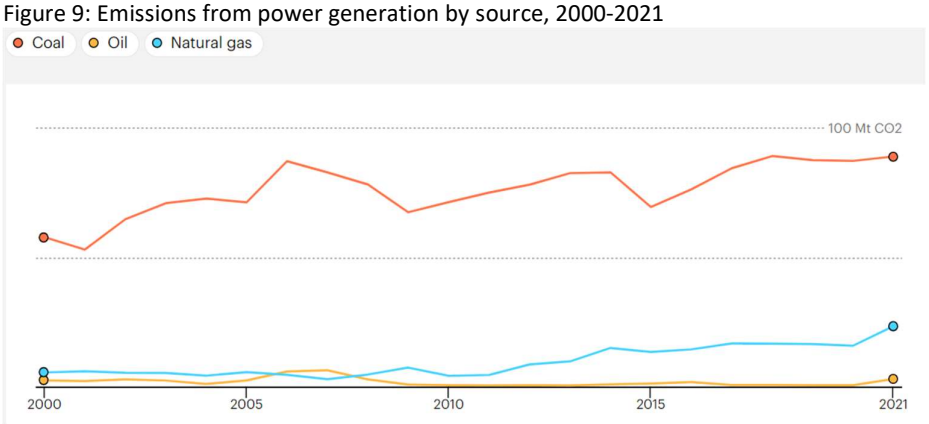
Source: IEA, https://www.iea.org/countries/kazakhstan/energy-mix#how-is-energy-used-in-kazakhstan

Figure 8: Electricity generation by source, 2000-2021



Source: IEA, https://www.iea.org/countries/kazakhstan/electricity#where-does-kazakhstan-get-its-electricity

Figure 9: Emissions from power generation by source, 2000-2021



Source: IEA, https://www.iea.org/countries/kazakhstan/electricity#what-is-the-climate-impact-of-electricity-generation-in-kazakhstan