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Key forecasts and prospects for green transition in the region of Central Asia beyond 2022

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Abstract

Background The transition to energy-sustainable systems is a globally accepted concept, but it is implemented with various degrees of success around the world. The aim of this paper is to determine the status of green transition in five Central Asian countries (Tajikistan, Turkmenistan, Uzbekistan, Kazakhstan, and the Kyrgyz Republic) that are among the highest energy consumers globally and the most vulnerable to climate change. Despite a notable improvement in living conditions across all countries over the past two decades, the region remains underdeveloped. Economic growth is based on the export of natural resources and remittance inflows, but the structure of the economy is monolithic.

Main findings Upon analysing transition indicators for the period 2000–2020, no evidence of significant changes towards a sustainable energy transition is found. All countries in the region (except Uzbekistan) have recorded an increase in carbon emissions, while the carbon intensity of the energy mix is almost the same. While there has been visible progress in reducing energy intensity, the countries in the region remain among the most energy-intensive economies. Despite the region's substantial potential for renewable energy production, it remains underutilized.

Conclusions A multitude of varied problems accompanies the green transition in Central Asian countries. The energy market that has not yet been liberalised, along with significant subsidies and low energy tariffs, discourages investments in renewable energy sources and energy efficiency initiatives. A high level of corruption, rigid legislative and institutional infrastructure, and insufficient capital are additional factors that determine the speed, scope, and effectiveness of the green transition. Thus far, the primary focus in these countries has been on ensuring energy security. However, there has been a discernible surge in investments (particularly from China) in renewable energy projects. Although energy efficiency and climate change issues are formally defined, the energy transition goals are often declarative without an action plan that provides concrete steps in transition process. Strategic planning of economic development that includes all related sectors (not only the energy sector) and paying attention to socio-economic and environmental indicators of sustainable development are prerequisites for successfully implementing the energy transition in these countries.

Keywords Economic transition, Green transition, Energy policy, Macroeconomy, Sustainable development, Central Asia

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Background

The historical increase in energy production and consumption opens not only the issue of the depletion of non-renewable energy resources but also the discussion about the causes of climate change and the measures that should be taken in order to reduce the damage caused by climate change. The nature of the occurrence and cause of climate change is a matter of dispute, because there are diametrically opposed opinions. Unlike the Intergovernmental Panel on Climate Change, which directly explains climate change as a consequence of the increase in greenhouse gas emissions, some studies show that climate change is a natural phenomenon in the history of the planet Earth [1, 2] and that various other factors can cause it. Therefore, it is not possible to establish a widely recognised methodology that unequivocally attributes specific damage exclusively to the effects of climate change and suggests that it can be prevented solely by halting global warming. In addition, the inconsistency between the temperature and emission-based targets was found [3]. Defined climate targets certainly require a review of all factors and models and an assessment of the expected effects [4]. At the same time, the first analyses (performed in the most developed industrial countries) show that there are differences in the effectiveness of the changes being implemented [5], with possible long-term adverse effects of climate neutrality efforts on the economy [6]. In addition, there are different views, assessments, and predictions of future climate change scenarios and, accordingly, the impact on the socio-economic position of countries [7].

So far, certain advances have been made at the international level regarding the consensus that joint action by all countries is necessary for reducing greenhouse gas emissions. Thus, the Paris Climate Agreement (Conference of the Paris COP: 21) from 2015 was the first international agreement signed by 196 countries to acknowledge the urgency of limiting greenhouse gas emissions to achieve climate neutrality. Implementation of the Paris Agreement requires economic and social transformation, which implies major changes in the energy sector, industry, transport, and agriculture, but also in all other areas such as science and education in order to form an adequate workforce ready to respond to the new requirements of the green transition. All these changes imply the formulation of a strategy that should enable transformation towards carbon neutrality, as well as the implementation of specific policies and a legislative framework [8]. The main directions leading to the reduction of carbon emissions are numerous, but the key prerequisites are the reduction of the use of fossil fuels, the broader application of renewable energy sources, and the improvement of energy efficiency [9]. In order

to implement carbon neutrality, numerous economic instruments are available, starting with carbon taxes, the reduction of subsidies on fuel, the introduction of subsidies for greater use of renewable energy sources, etc. [10].

Considering the level of development achieved, the approach to decarbonisation differs a lot between countries. The European Union, as a leader in the implementation of the net zero transition, has defined an ambitious long-term climate neutrality strategy until 2050 with elaborate plans and financial and institutional support [11]. On the other hand, there are countries and entire regions where the energy transition is proceeding slowly or where there is almost no insight into the state of the energy transition. Likewise, there are countries that do not have clearly defined strategic plans for combating climate change, nor do they undertake to implement certain activities leading to climate neutrality for a large number of reasons. Most often, these are insufficient diversification of the economy, lag in technological development, lack of financial resources [12], lack of capacity building, underdevelopment of institutions, and governance [13].

Governance is essential for the entire process of implementing the strategy towards carbon neutrality, because it is a long-term planning process in which defining adequate goals, measures, and activities, as well as monitoring and evaluating the process, play an important role. Efficient governance requires the availability of data, their comparability based on internationally accepted methodologies, and transparency. In addition, it is necessary to establish a defined regulatory framework and action plans that specify the competent institutions, timelines, and available funds for the implementation of what is envisaged [14]. If these prerequisites are not met, the entire process of climate neutrality can be called into question, especially from the point of view of implementation in accordance with the goals of sustainable development, which insist on all three aspects—social, economic, and environmental [15, 16]. The assessment of countries' commitment towards carbon neutrality has to be carried out with consideration of additional aspects, which primarily include cultural, historical, social, and political specificities [17].

The aim of this paper is to determine the status of energy transition in five Central Asian countries (Tajikistan, Turkmenistan, Uzbekistan, Kazakhstan, and the Kyrgyz Republic) that are among the biggest energy consumers globally and the most vulnerable to climate change [18]. Since food production and water and energy resources are directly exposed to climate challenges, sustainable development of the Central Asian region is directly endangered. In addition, the region faces economic challenges common to landlocked developing countries that lack transport connectivity with

the outside world (the transport network was concentrated in Russia and other Soviet republics). Despite their shared historical legacy as former Soviet Union states under central planning, Kazakhstan and Turkmenistan have achieved upper-middle-income status, whereas Kyrgyzstan, Tajikistan, and Uzbekistan remain in the lower-middle-income category. Besides, these countries have suffered from political instability and unstable neighborhoods (e.g., the civil war in Afghanistan, the India–Pakistan conflict, and strained relations in the Southern Caucasus) that have limited intra-regional cooperation. Compared to other regions, these countries are understudied, and therefore, statistical data (especially for Turkmenistan and Uzbekistan), national documents, and analysis are scarce, which was an additional challenge for research.

Economic transition and current macroeconomic stability of the Central Asian countries

The Central Asian region covers a territory about twice the size of Western Europe, and according to data for 2023, the region is inhabited by slightly more than 78 million people. The population has increased 1.4 times in the last two decades, and the most populated countries are Uzbekistan (about 35.1 million) and Kazakhstan (about 19.6 million), followed by Tajikistan (10.1 million), the Kyrgyz Republic (6.7 million), and Turkmenistan (6.5 million). The majority of the population lives in rural areas, with an average population density of only 20 people per square kilometer.

The region is quite isolated, as none of the countries in the area has access to the sea (the Caspian Sea is not considered an open sea). Therefore, the possible access to the sea is through the Russian Federation or Iran (Uzbekistan is classified as double-landlocked as it requires crossing two borders to reach the sea). In addition, other geographic barriers, including harsh winters and high mountains in Tajikistan, make transportation and communication more difficult, while energy and transit costs are much higher [19]. On the other hand, the region is rich in oil, natural gas, uranium, cotton, gold, copper, aluminum, and iron. Kazakhstan and Turkmenistan export natural gas and oil, while Kyrgyzstan and Uzbekistan export gold. Kazakhstan is among the ten countries with the largest coal reserves, and Uzbekistan is among the ten largest gas producers in the world. In addition, these two countries have 20% of the world's proven uranium reserves [20]. Exports of raw materials account for 30–88% of total exports in resource-rich countries, significantly contributing to fiscal revenues and providing resources for investments. Tajikistan is considered the least developed in the region due to its scarce reserves

of fossil fuels and raw materials and its underdeveloped industry.

During the Soviet period, Central Asian countries, as part of an integrated centrally planned production system, delivered raw materials, energy, and intermediate inputs and received final products from more developed Soviet republics. The Central Asian republics developed neither international economic relations nor international trade. Such a position of the Central Asian region in the former Soviet Union resulted in their industry being undeveloped, and the existing small number of industrial enterprises were state-owned and centrally managed. With the collapse of the unified state, the industry in the Central Asian countries was left without subsidies, while on the other hand, they did not have qualified management ready to improve production and implement the restructuring of the economy. The loss of the former Soviet Union market and lack of international trade contacts were crucial factors that pushed their economies into a deep recession.

After the dissolution of the Soviet Union in December 1991, five Central Asian countries became independent and opted for the transition from a centrally planned to a market economy. As these countries lacked established market transformation programs, in the 1990s, they initiated the transition from a centrally planned economy to a market economy system. However, the economic transition process was delayed and varied in terms of success and speed across these countries. The Soviet ruble was used as a common currency until 1993 (Tajikistan introduced its currency in 1995). The process for achieving macroeconomic stability commenced in 1994–1995, and in Turkmenistan, it began in 1997 following the conclusion of the civil war that lasted from 1992 to 1997. The process of economic transition required comprehensive economic reforms, which encountered resistance attributed mainly to the availability of natural resources whose exports provided foreign currency inflow, high level of corruption and adaptability of governments. The market reform process was the slowest in Turkmenistan and Uzbekistan, countries still characterized by instruments of a command economy [21] and a significant level of corruption. Even though corruption has decreased over the past decade, according to 2022 Transparency International data, Uzbekistan is ranked 126th and Tajikistan 150th out of 180 countries [22].

In the aftermath of the Soviet Union's collapse, all countries faced fiscal deficits financed by money emissions that resulted in hyperinflation (Table 1). In an effort to achieve macroeconomic stability, these countries launched IMF-sponsored reform programs, resulting in a significant degree of dollarization. However, the strengthening of the dollar and the collapse of oil

Table 1 End-of-year inflation, in %

	1993	1994	1995	1996	1997	1998	1999
Kazakhstan	2.165	854.6	60.4	28.6	11.3	1.9	18.1
Kyrgyz R	929.9	62.1	32.1	34.8	13	16.8	39.9
Tajikistan	7.344	1.1	2.144	40.5	163.6	2.7	30.1
Turkmenistan	na	1.327	1.261	445.8	21.5	19.8	20.1
Uzbekistan	884.8	1.281	116.9	64.4	50.2	21.6	26.0

Source: [24]

prices put additional monetary pressure on Russia, so it abandoned the USD currency band on August 17, 1998, which led to a ruble devaluation of three quarters of its initial value. This was followed by the devaluation of national currencies in the countries of Central Asia (currency depreciation in Kazakhstan was 41%, in the Kyrgyz Republic 54.7%, and in Tajikistan 37.9%), as well as a series of currency crises that followed in the next 20 years [23].

Hyperinflation and devaluation negatively affected macroeconomic, structural, and institutional reforms, making a significant contribution to output decline. In the period 1990–1996, the volume of production fell between 40% and 60% in all countries except Uzbekistan, where real production decreased by less than 20%. Although the recession and decline in production were also recorded by other countries that decided to switch to a market economy system, this region still has the peculiarity of having been part of one country for many decades, having certain geographical characteristics, and the availability of natural resources. In the first years of macroeconomic stabilisation, the priority was to carry

out price and exchange rate reforms, as well as structural adjustment programs [25, 26], that considered stabilization of public finances, liberalization of trade flows, restructuring and privatization of state enterprises. Only after the first decade of market reforms, which were accompanied by an economic recession, did some countries gradually return to the pre-transition gross domestic product level of 1990 (Fig. 1). Economic growth was recorded in the 2000s; however, growth rates were volatile mainly because they were driven by the export of commodities (oil and natural gas from Kazakhstan, Turkmenistan and Uzbekistan; gold from Kyrgyzstan; aluminum from Tajikistan; cotton from Tajikistan and Uzbekistan; and uranium and metals from Kazakhstan) that are prone to fluctuations. Uzbekistan managed to reach the pre-transition gross domestic product level in 2001, Turkmenistan in 2002, and Kazakhstan in 2004. However, in 2004, Kyrgyzstan reached only 80.4% of the pre-transition gross domestic product, and Tajikistan only 55.8% [27]. Besides the macroeconomic stability program, other factors boosted economies of these regions—the increase in the prices of energy and export

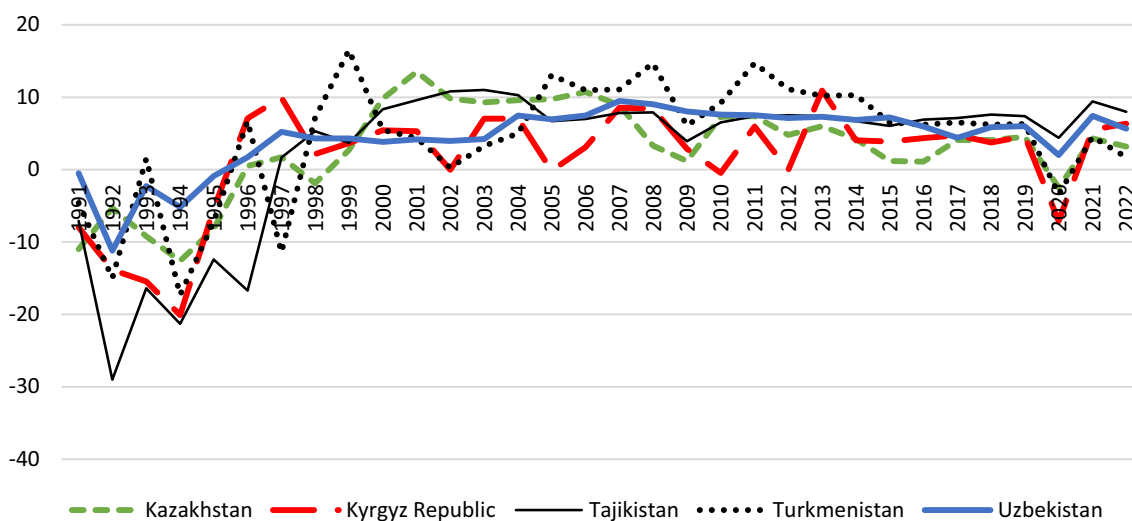


Fig. 1 GDP growth rate in %. Source: [30]

raw materials (including agricultural products) and the inflow of foreign direct investments, especially in the energy sector [28, 29].

The lack of development of economic ties with foreign countries and decades of dependence on other Soviet republics, highlighted the necessity for countries to undertake reforms and attract foreign investments in the aftermath of the economic collapse experienced by the entire former Soviet Union. Transport bottlenecks and taxes on transfers with Russia and within the region increased costs and reduced attractiveness for domestic and foreign investors alike. However, it took a long time to build relationships with foreign companies outside of Russia and to attract foreign investment to increase production capacity in natural resources. The first step was the establishment of a regulatory and institutional framework with numerous investment-friendly provisions and the liberalization of trade relations [31]. Meanwhile, countries entered into bilateral investment treaties and became members of the World Trade Organization (Kyrgyzstan in 1998, Tajikistan in 2013, and Kazakhstan in 2015), the Eurasian Economic Union, and various others that helped them to modernize and harmonize customs administration and technical standards and reduce non-tariff barriers and administrative barriers to investment.

In the first years, the region received significant investments from international financial institutions. Individually, the major investors were China, the Russian Federation (the biggest investor in the period 2019–2021 followed by China) and the European Union [32]. The decrease in FDI inflows was evident during the global economic crisis [33], but the negative effects of the global economic crisis were far more pronounced in countries that were more advanced in implementing transitional reforms [34]. Since 2010, Uzbekistan and Turkmenistan have relied mostly on China as an investor in the extractive sectors, because China is the main importer of gas from these countries. At the same time, China is increasing its investments in Kazakhstan, a country with a far more diversified structure of oil and gas exports. If the trend of investments in the last three decades is analyzed, it can be noted that since 2010, investments in resource-rich Kazakhstan and Turkmenistan have gradually declined, while the inflow in Kyrgyzstan and Tajikistan has been unstable without a clear trend. For example, the share of global foreign investments in Central Asia was nearly three times smaller in 2019 than in 2009 [35]. Such a trend is not unique to the region. Although foreign direct investments generally declined in all countries of the region in the decade before the COVID-19 outbreak, Uzbekistan experienced an increase in investments since 2015. One possible reason is that Uzbekistan rose 72 notches

in the World Bank's "ease of doing business" rankings to the 69th position globally. In order for the inflow of investments to be greater in the Central Asian region, liberalization, human capital, rule of law, and democratization are necessary.

During the last two decades the average annual economic growth rate in Central Asian countries was 6.2%, which is higher than the average growth rate for emerging countries (5.3%). The countries of Central Asia base their economic development on high inflows from remittances and income from the export and/or transit of energy resources [36]. According to the World Bank [37], Tajikistan, Kyrgyzstan, and Uzbekistan are among the most remittance-dependent countries. Tajikistan is the leader, with the share of remittances accounting for 50.9% of its GDP in 2022. The share of remittances in the Kyrgyz Republic amounted to 27.9%, and in Uzbekistan, it amounted to 20.8%. Significant remittance inflows to these countries come from the Russian Federation, owing to the size of its economy and historical ties. During 2022, there was a significant influx of residents and the relocation of companies from Russia, resulting in increased demand, income and money transfer, which led to increased deposits and boosted profits in the banking sector [38]. Even though remittances have always been the most important source of support and financing for Central Asian countries through reduction of current account deficits, the high share of remittances highly expose these countries to external shocks [39].

Kazakhstan is the largest producer and exporter of fossil fuels in Central Asia, while Turkmenistan is the largest producer and exporter of natural gas in the region. Oil exporters are Kazakhstan and Turkmenistan, whereas Uzbekistan has oil reserves, but only for its own needs. Gas exporters are Turkmenistan, Kazakhstan, and Uzbekistan. Kazakhstan, as the most developed economy in the region, generated approximately 81% of its export revenues from exports of oil and metals over the past two decades (2001–2021). Since the diversification of the economy is insufficient, the economy has a monolithic export structure and is exposed to external shocks due to the high volatility of global commodity prices. Similarly, in Turkmenistan, mineral fuel accounted for 87% of 2021 exports; in Tajikistan, gold and precious stones and ore concentrates had the dominant share in exports, at 41.7% and 24.3%, respectively. The export of gold dominates in the export structure of Uzbekistan (29.2% of total exports) and of the Kyrgyz Republic (26.6%), followed by the export of food (10% and 20%, respectively). The region's leading export partners are Russia (growth of exports to Russia recorded in 2022—in Kyrgyzstan at 35.9%, Uzbekistan at 16.3%, and Kazakhstan at 9.8%) and China [40].

Current macroeconomic overview based on the latest data for the Data for the first half of 2023 (Table 2) show that the growth projections have been upgraded, as these countries absorbed a significant influx of people and companies and recorded an increase in trade and money flows over the last 2 years. This influx boosted economic growth, lowered inflation, and supported currency appreciation. The main drivers of Kazakhstan’s current economic growth (4.27%) are the construction sector, fixed investments, and retail trade turnover. Kyrgyz Republic’s economic growth (3.55%) is based on increased aggregate demand, industrial production, and the transport sector. Tajikistan’s growth (5%) is mainly fueled by industrial production and agriculture, while Turkmenistan (2.3%) increased natural gas production and export. Uzbekistan’s economic growth (5.2%) is supported by growth in services. Owing to economic growth, the standard of living has improved significantly. According to World Economic Outlook data for 2023 [41], Turkmenistan (13.07 thousand) and Kazakhstan (12.31 thousand) have the highest standard of living, followed by Uzbekistan (2.56 thousand), the Kyrgyz Republic (1.74 thousand), and Tajikistan (1.28 thousand). Inflationary pressure is present in the region, and inflation is in single digits only in Tajikistan. Unemployment is low in Kazakhstan, and in Uzbekistan and Kyrgyzstan, it is around 9% (data for Turkmenistan and Tajikistan are not available).

The main sustainable development challenges for the Central Asian countries

Despite the relatively high economic growth rates and improvements in living standards that Central Asian countries have achieved in the past two decades, the region is still underdeveloped. According to the latest Human Development Report for 2021/22 [43], which included 191 countries in the analysis, apart from Kazakhstan, which is ranked 56th, the other countries of the Central Asian region fare rather poorly in the

ranking—Turkmenistan 91st, Uzbekistan 101st, Kyrgyzstan 118th, and Tajikistan 122nd. The position of Tajikistan is directly related to its status as a relatively small and resource-poor country (in comparison with other countries in the region) and to the fact that the country’s standard of living, education, and infrastructure development suffered from a civil war from 1992 to 1997. Addressing the water supply and mitigating the effects of climate change, to which the region is highly exposed, is crucial for further economic development. In addition, it is necessary to improve the regulatory and institutional framework and eliminate bottlenecks in regional transport networks.

The main structural challenges that have influenced sustainable development of these countries are: lack of access to the sea [44], dependence on resources and low level of development of the financial sector, lack of coordination in the management of the water-energy complex, and climate change.

According to the latest Sustainable Development Report for 2023 [45], Kyrgyzstan is ranked as the best-performing (45) country, followed by Kazakhstan (66), Uzbekistan (69), Tajikistan (85), and Turkmenistan is ranked as the worst-performing (91) country in the region (Table 3). Common to all countries of the region are major challenges in achieving SDG 15 (life on land) and SDG 16 (peace, justice and strong institutions). In addition, Kazakhstan faces substantial obstacles in achieving SDG 8 (decent work and economic growth), while Kyrgyzstan (66) is greatly challenged with achieving SDG 2 (zero hunger), SDG 7 (affordable and clean energy) and SDG 13 (climate action). Uzbekistan is ranked 69th, with SDG 3 (good health and well being), SDG 6 (clean water and sanitation), and SDG 7 representing its significant challenges. Tajikistan is ranked 85th and challenged with SDG 3 and SDG 9 (industry, innovation and infrastructure). As the worst-performing country in the region, Turkmenistan faces additional challenges: SDG 3, SDG 6, SDG 7, SDG 8, SDG 9 and 17 (partnership for the goals).

Table 2 Main macroeconomic variables for 2022

	GDP growth rate, constant prices, %	GDP per capita, USD	Inflation, average, %	Unemployment rate, %
Kazakhstan	3.2	11,439	14.9	4.9
Kyrgyz R	7.0	1626	13.9	9
Tajikistan	8.0	1064	6.6	na
Turkmenistan	1.79	12,499	11.4	na
Uzbekistan	5.67	2279	11.4	8.8

Source: [42]

Characteristics of the energy sector in the Central Asian region

The most important energy resources of Central Asian countries are coal, oil, natural gas, and hydropower, but they are unevenly distributed. Kazakhstan, Uzbekistan, and Turkmenistan have significant reserves of oil, gas, and coal, while Tajikistan and the Kyrgyz Republic have hydropower potential, but still largely unused (Kyrgyzstan uses about 13% and Tajikistan about 5% of its hydropower potential). In total, Kazakhstan has the largest energy reserves, while Tajikistan and Kyrgyzstan have the smallest. This data can be closely linked with economic development, which in these countries is based

Table 3 The major challenges in achieving sustainable development in 2023

SDG 2	Zero hunger	Kyrgistan
SDG 3	Good health and well-being	Uzbekistan, Turkmenistan, Tajikistan
SDG 6	Clean water and sanitation	Uzbekistan, Turkmenistan
SDG 7	Affordable and clean energy	Kyrgistan, Uzbekistan, Turkmenistan
SDG 8	Decent work and economic growth	Kazakhstan, Turkmenistan
SDG 9	Industry, innovation, and infrastructure	Tajikistan, Turkmenistan
SDG 13	Climate action	Kyrgistan
SDG 15	Life on land	All countries of the region
SDG 16	Peace, justice, and strong institutions	All countries of the region
SDG 17	Partnership for the goals	Turkmenistan

Source: [46]

on the export of energy resources. In order to gain a better insight into the availability of energy resources in the countries of Central Asia, they are compared with data for the Russian Federation. Table 4 shows that Kazakhstan’s energy reserves are 11 times less than the Russian Federation’s. Kazakhstan has by far the largest coal and oil reserves, whereas Uzbekistan has the largest gas reserves. Natural gas (of which 75% is consumed in Uzbekistan) and coal (Kazakhstan consumes about 93% of its reserves) are the most used energy sources in the region. The region has enormous potential for renewable energy resources. However, the current deployment of these resources is still low [47]. Kazakhstan has the greatest potential for renewable energy resources [39], especially solar and wind. Uzbekistan and Turkmenistan also have potential for solar energy, and Turkmenistan has potential for wind energy [48]. Considering investments in renewable energy projects, Kazakhstan is ahead of other countries in the region and is the only country in the region to have met the goal of producing 3% of electricity from renewables by 2020.

The region has significant energy resources, but the energy infrastructure is mostly outdated and environmentally unacceptable. Most of the energy infrastructure originates from the Soviet period, and investments are required for both the rehabilitation of existing energy capacities and the development of new ones. The

connection with the Russian Federation is visible in all countries of the region, and the focus is on cooperation in the fields of security, energy, and trade [50]. China [51, 52], which has surpassed Russia in terms of the volume of investments in the energy sector, also has a significant role in creating the energy future (including the issue of sustainability). Bearing in mind the policies of the mentioned two countries regarding sustainable development as a whole and their geopolitical interests [53], the countries of the region are more oriented toward the delivery of fossil fuels than investments that prioritize green transition. A major limitation for attracting investments in the region’s energy sector is the fact that the energy sector is owned by state monopoly companies that receive substantial state subsidies and, therefore, may set low energy prices, which are one of the basic instruments of social policy. Since the market conditions are not developed, a reform of the energy sector is necessary and should be preceded by the adoption of a regulatory and institutional framework. However, a high level of bureaucracy and corruption and the practice of presidential decrees, which are present in all countries, invalidate certain decisions [54].

Kazakhstan is the largest oil producer in Central Asia (80% of production is exported) and a large producer of coal and gas. These three energy resources contribute to the creation of gross domestic product with around

Table 4 Total energy supply 2020, TJ

	Coal	Oil	Gas	Hydro	Renewables	Total
Russian Federation	4,796,311	6,270,165	17,111,262	765,311	481,121	31,728,611
Kazakhstan	1,365,432	495,894	844,618	34,777	449,081	2,749,502
Uzbekistan	121,629	179,830	1,566,079	17,997	11,499	1,894,736
Turkmenistan	–	287,202	783,262	11	397	1,059,350
Kyrgyz R	42,939	52,875	11,890	50,325	58	158,270
Tajikistan	40,236	45,021	8122	65,210	–	153,219

Source: [49]

17%. In addition, with a 43% share in world production, Kazakhstan is the world's largest producer of uranium [55]. Kazakhstan has been successful in attracting foreign direct investment in the oil and gas sector, but due to the global trend towards decarbonisation and relatively high costs for new upstream projects, investors are becoming more selective. Kazakhstan has great potential in the sector of renewable energy sources and plans to increase the participation of these sources in electricity production (not including large hydropower plants) to 15% by 2030. However, balancing the system is a big challenge. An additional limitation is that investments in renewable energy projects are still not sufficiently attractive to investors due to low energy prices. Although energy prices in Kazakhstan are not directly subsidized, they are low, because the regulatory system does not fully consider maintenance and replacement costs, as well as external impacts on the environment and climate. This is one of the reasons why investments in renewable energy sources are not attractive in terms of price compared to coal, which is cheap and available in large quantities (Kazakhstan's coal reserves are among the largest in the world). Therefore, coal accounts for more than 70% of the energy production and more than 20% of final consumption. However, due to the outdated, inefficient, and highly polluting coal-fired thermal power plants, Kazakhstan falls within the group of ten countries with the highest energy intensity [56].

Uzbekistan has the largest natural gas reserves in the region, so gas accounts for about 85% of the country's total energy consumption and is the main source of energy in all sectors. Gas is also the country's primary source of export revenue. However, the government plans to cease exports by 2025 and use gas for petrochemical production and domestic energy supply. However, if consumption continues at the current rate, the country's gas reserves will be exhausted in less than 20 years. Uzbekistan has substantial renewable energy potential (mainly hydro and solar), but their more significant use requires energy sector reform [57–59].

From the 1990s to 2017, Turkmenistan provided all citizens with free natural gas, electricity, and water. In 2017, the President imposed limitations on the number of free utilities by decree, and in 2019 the free supply was canceled due to the deterioration of the economic situation in the country. Due to the termination of access to free utility services, many citizens are unable to pay utility bills, even though electricity prices are among the lowest in the world. Given the presence of state monopolies in the energy sector, there are no indications that third parties can enter any market segment. The main barriers to investment are state monopoly, unregulated market,

low energy prices, and lack of legislative framework and information.

Although rich in energy, these three Central Asian countries are economically underdeveloped, and their development has thus far relied on income generated by the export of energy products. In order to improve energy security in the coming period and comply with the commitments made in terms of reducing carbon emissions, these countries are trying to monetize their fossil fuel reserves by advancing in the value chain, developing the chemical industry, or finding new export destinations. In addition, these three countries recognize their renewable energy potential as a strategic resource that can help them increase their oil and gas exports, attract foreign investment, strengthen energy security, decarbonize energy-intensive exports, and improve their international image. For example, Uzbekistan and Kazakhstan are exploring the possibility of producing low-carbon and renewable hydrogen or ammonia for domestic use and export. There is also interest in expanding the production of materials critical to the energy transition [60]. However, it seems that the future energy geopolitics of these countries will be defined as a compromise between the global green transition pressure and domestic-level pressures, particularly interest in hydrocarbon rents and regime stability as the most important [61].

The Kyrgyz Republic and Tajikistan have fewer energy resources at their disposal than the three Central Asian countries mentioned above, but unlike the latter, they have hydropower potential. Contrary to the countries rich in fossil fuels (Kazakhstan, Uzbekistan, and Turkmenistan), Kyrgyzstan and Tajikistan consider renewable energy as a means to reduce their dependence on energy imports from neighboring countries. Electricity production in these two countries relies almost entirely on the operation of hydropower plants, resulting in much lower levels of CO₂ emissions compared to those in other countries in the region. However, these countries are experiencing a problem with the security of supply due to hydrometeorological conditions, and therefore, coal exploitation is growing in both countries, thus threatening to have a negative impact on carbon emissions. The exploitation of domestic coal reserves has been initiated, because both countries are forced to rely almost entirely on oil and gas imports, primarily from Russia and Kazakhstan.

The Kyrgyz Republic exploits coal and a portion of oil and gas reserves, but more than half of its oil and gas needs are met through imports, especially during the winter months when hydropower production is low. Due to pronounced seasonal effects in hydropower potential, which directly affect the amount of electricity, Kyrgyzstan imports certain amounts of electricity from Tajikistan

and Kazakhstan. Because of problems with the stability of the electric power system, the government turned to the exploitation of existing coal reserves, so coal production has more than quadrupled since 2010. The current energy policy aims to improve energy security by developing domestic energy sources (mainly hydro and coal) and by rehabilitating and expanding transmission and distribution networks. Kyrgyzstan's energy sector suffers from a lack of investment and is characterized by outdated infrastructure and significant losses. The country has potential in renewable energy sources, but in order to encourage investments, it is first necessary to reform the tariff system and develop a legislative framework with appropriate incentives [62, 63].

Tajikistan has significant hydropower capacities, while oil, gas, and coal are imported. Tajikistan ranks eighth in the world in terms of hydropower potential (however, only 4% is used) and has some of the largest hydroelectric power plants (HP)—the Nurek HPP from 1972 and the Rogun HPP that is under construction. The exclusive reliance on hydroelectric power plants is a problem in the electricity supply, so it is necessary to diversify production and reconnect with the Central Asia Power System by the end of 2023 (interruption since 2009 due to a dispute with Uzbekistan). In addition, the inefficient power system requires significant investments for the overhaul of hydropower plants [64], as well as for the transmission and distribution network (the level of losses is about 15.5%, which is twice the average of the IEA member countries). However, the investment climate is still unfavorable, and there is a high level of bureaucracy and corruption at all levels [65]. Coal production has grown significantly since 2007 and is expected to continue growing as the government refurbishes power plants and builds new coal-fired generation. In this way, energy security will undoubtedly be improved, but this approach is not aligned with the decarbonization policy [66]. In addition, the government encouraged industries to switch from natural gas and oil to coal, resulting in strong demand and high year-over-year production growth. Tajikistan is very exposed to climate change and natural disasters. Tajikistan's geographic proximity to some of the fastest-growing energy markets in the world means that investment in developing its hydropower potential can contribute to regional energy security and clean energy transition, in addition to addressing Tajikistan's high vulnerability to climate change and natural disasters.

The way ahead to green transition

Despite its significant and diverse energy resources (fossil and non-fossil), the Central Asian region faces a complex energy security crisis, especially in rural areas where the population struggles to meet basic energy needs due

to poor infrastructure of the energy supply system and geographical isolation from main centers of energy production. According to UNECE estimates [67], in order for the region to ensure a reliable supply of electricity, investments of around 1.407 trillion dollars are necessary by 2050 in renewable energy projects, the construction of transmission and distribution networks, and the improvement of energy efficiency.

In addition to reliable supply, the Central Asian region is one of the most vulnerable regions to climate change. According to the 2009 World Bank report [68], it is estimated that by 2030, the temperature in the region will rise by 1.6°C to 2.6°C, which will affect the precipitation levels, exacerbating the existing problem of water shortage. Certain Central Asian countries face severe water supply problems. Therefore, the supply relies on bilateral agreements with neighboring countries (energy-for-water agreements). Bearing in mind the importance of water supply, the aforementioned issue also poses a constraint on the implementation of the energy transition [69]. It was established that the region's vulnerability to climate change is a result of inefficient resource use, outdated and environmentally unacceptable energy infrastructure, limited application of regulations, and an inherited severely degraded environment.

According to 2020 IEA data, there is no evidence of significant changes towards a sustainable energy transition in the countries of Central Asia, as measured by the reduction of CO₂ emissions [70]. According to the latest available IEA data [49] on CO₂ emissions in absolute terms (measured in Mt CO₂), over the entire observed period 2000–2020, the lowest level of CO₂ emissions is recorded in the Kyrgyz Republic and Tajikistan, and the highest in Kazakhstan (Fig. 2). The emission level in Kazakhstan is about 30 times higher than that in the Kyrgyz Republic and Tajikistan, which mainly use hydropower potential. At the same time, Kazakhstan surpasses the latter two countries in terms of population size and economic development. At the beginning of 2000, Uzbekistan recorded the highest emission level, and from 2002 on, Kazakhstan surpassed Uzbekistan and continued to record twice as high emission levels. Kazakhstan not only records the highest emission level in the region by far but has also witnessed an almost 83% surge in the emission level since 2000. The increase in emissions results from the increase in coal usage for electricity generation and the surge in emissions from the transport and residential sectors. What is worrying is that all countries in the region, except Uzbekistan, have recorded an increase in emissions. Despite having the lowest emission levels, compared to the year 2000, Kyrgyzstan recorded an 84% increase in its emission level, while Tajikistan saw a rise of 232%.

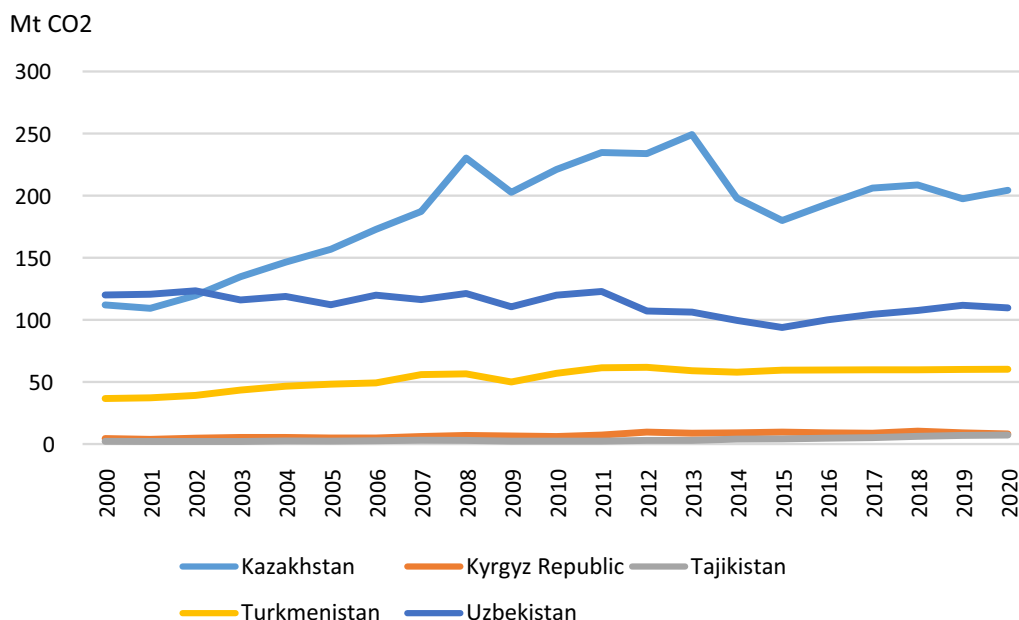


Fig. 2 CO₂ emission, Mt CO₂. Source: [49]

However, when examining the CO₂ intensity of the energy mix, expressed as CO₂ per total energy supply, it can be concluded that Uzbekistan, Turkmenistan, and Kazakhstan maintained similar levels of carbon intensity in 2020 compared to 2000 (Fig. 3). On the other hand, Tajikistan and the Kyrgyz Republic, as countries

with the lowest levels of carbon intensity, recorded an increase of 96% and 13%, respectively.

Analysis of the energy intensity (measured as TES/GDP in PPP) reveals visible progress (Fig. 4). Energy intensity decreased across all countries, with Uzbekistan reporting the largest decrease (82%), and Kyrgyzstan the smallest (20%). Despite achieving a

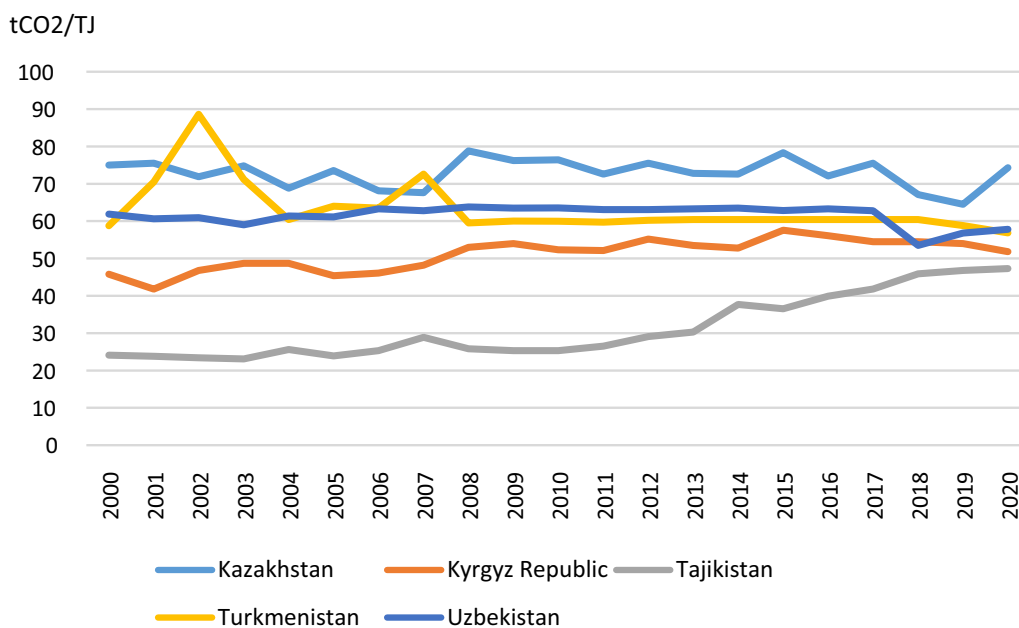


Fig. 3 CO₂ intensity of energy mix (CO₂/TES), t CO₂ TJ. Source: [49]

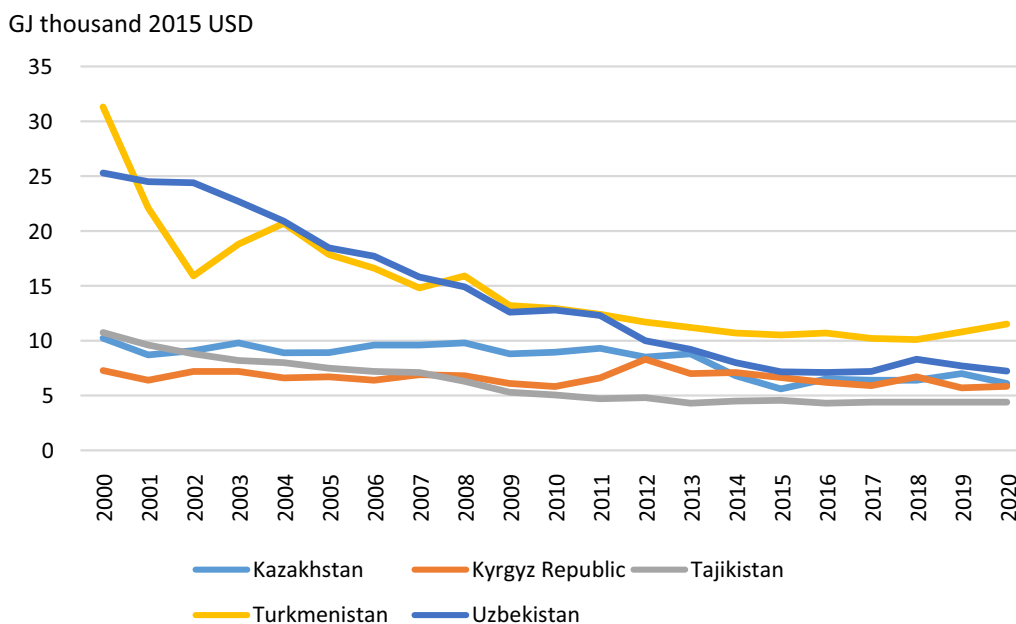


Fig. 4 Energy intensity TES/GDP in PPP, GJ thousand 2015 USD. Source: [49]

decrease of around three-fourths in CO₂ intensity from 2000 to 2020, Uzbekistan still reports one of the highest levels of CO₂ intensity in the world, surpassing the global average of 0.26 kg CO₂/USD by 77% (at 2015 PPP). Notwithstanding a 59% reduction in energy intensity, Turkmenistan is still the most energy-intensive economy.

Key energy transition indicators are partly determined by population size and the level of economic development in terms of GDP per capita. Analysis of the 1998–2017 data for the Central Asian region revealed a positive correlation between per capita energy consumption and per capita GDP, indicating that the economic growth of the countries in the region still heavily relies on energy consumption. In addition, CO₂ per capita emissions negatively affect GDP per capita, while GDP per capita negatively affects energy consumption per capita [71].

The trend of population growth (Fig. 4) and the growth of living standards (Fig. 5) were recorded in all countries. Compared to 2000, population growth was most pronounced in Tajikistan (53%), followed by Uzbekistan (39%), Kyrgyzstan (35%), Turkmenistan (34%), and Kazakhstan (26%).

The growth of living standards measured as GDP PPP per capita (Fig. 6) in comparison to 2000 is most pronounced in Turkmenistan (246%), followed by Tajikistan (172%), Uzbekistan (146%), Kazakhstan (145%), and Kyrgyzstan (52%).

Actions towards the green transition

All Central Asian countries ratified the Paris Agreement and adopted Nationally Determined Contributions (NDC), in which they defined their national goals until 2030 regarding emission reductions (Table 5). It is clear that a considerable effort will be required to transition from fossil fuels to renewable sources in order for countries to meet their Paris Agreement commitments and transition to a low-carbon and sustainable energy system [72].

Kazakhstan formally started the green transition in 2013 when it adopted the “Concept for the Transition to a Green Economy”, followed by the Action Plan for the implementation of the Green Economy Concept (2020). By 2050, Kazakhstan aims to generate 50% of its electricity from “alternative or renewable” sources, including nuclear power. In addition, the plan is to reduce the emission level by 40% and the energy intensity by 50%. Draft Concept of Low-Carbon Development until 2050, NDC draft, and Roadmap for its implementation are being prepared. In January 2021, Kazakhstan adopted a new Environmental Code (the previous regulation was adopted in 2007). It provides for climate change mitigation and adaptation policies and establishes a “carbon budget” that should be aligned with the country’s international obligations. Kazakhstan is the first country in the former Soviet Union that introduced an emissions trading scheme (ETS), but the volume of transactions is still extremely low due to the presence of a large number

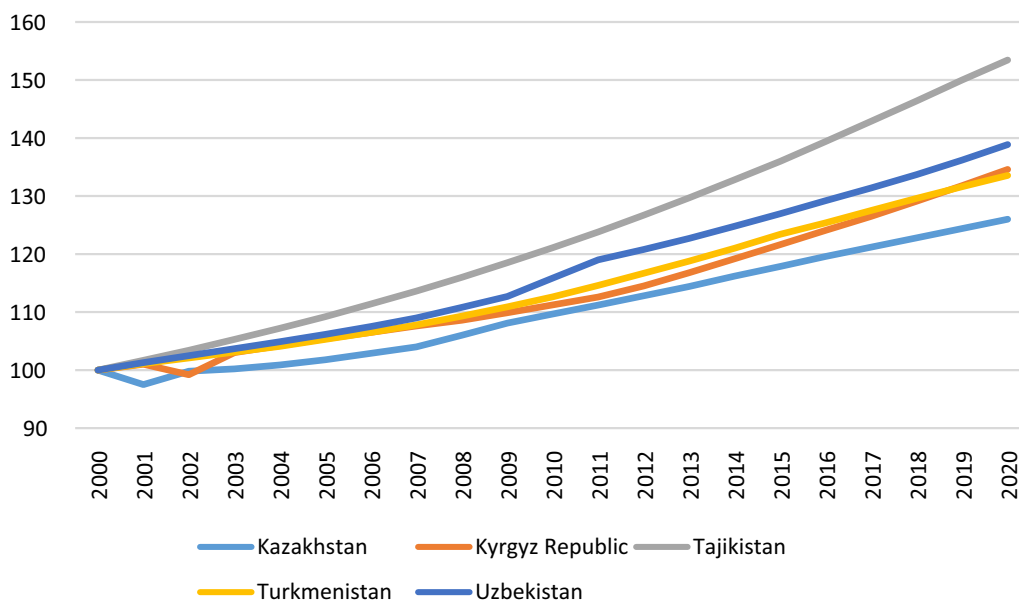


Fig. 5 Trend of population index (2000 = 100). Source: [59]

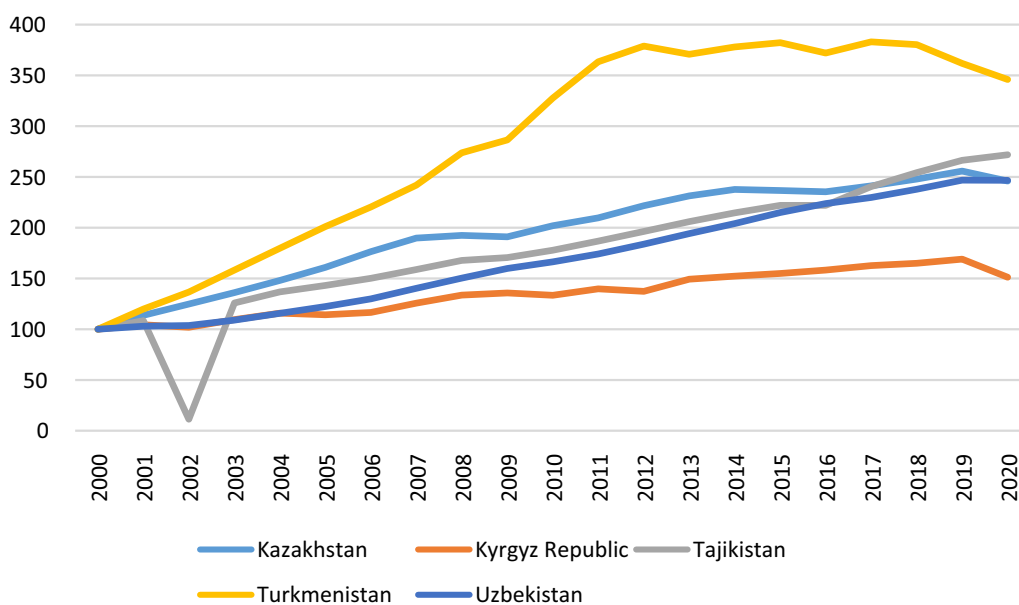


Fig. 6 Trend of GDP PPP per capita index (2000 = 100). Source: [59]

of free allowances and the exclusion of some sectors. Although the implementation of a sustainable energy transition has been declaratively accepted in Kazakhstan, the results are still modest [74], because economic development is based on the exploitation of resources [75]. The primary reasons cited include subsidized energy prices for domestic consumers, unfavorable investment climate, outdated infrastructure, and insufficient strategic and legal regulation [76]. Ultimately, decision-makers

appear to prioritize regional geopolitics over sustainable energy transition.

Uzbekistan has not set an absolute emissions reduction target, because the government expects that rapid population growth and economic development will increase energy consumption. The achievement of defined goals by 2030 is supported by two strategic documents: “Action Strategy for Five Priority Areas of Development of the Republic of Uzbekistan

Table 5 Paris Agreement ratification and NDC targets

	Paris Agreement ratification	The first NDC adoption	CO ₂ reduction target for 2030
Kazakhstan	December 2016	2016	15% below 1990 levels by 2030 as an unconditional target, and by 25% conditional on receiving additional international assistance
Uzbekistan	November 2018	2017	emission reduction per unit of GDP by 10% compared to the 2010 level
Turkmenistan	October 2016	2022	20% emission reduction under the “business-as-usual” scenario compared to 2010 emissions
Kyrgyz Republic	February 2020	2021	15.97% under the “business-as-usual” scenario and by 43.62% with international support
Tajikistan	March 2017	2021	40–50% reduction compared to 1990 levels, conditional on international support

Source: [73]

in 2017–2021” (focusing on reduction of energy and resource intensity, increase in energy efficiency and renewable energy, and the adoption of systemic measures to mitigate the adverse impact of global climate change and of the drying up of the Aral Sea) and “The Green Economy Transition Strategy 2019–2030” (aiming to increase energy efficiency, diversify energy consumption, mitigate climate change, and define measures to support green economy) [77]. Uzbekistan has yet to develop a long-term low-GHG development strategy, which is an obligation under the Paris Agreement. Together with the EBRD, Uzbekistan prepared the Roadmap to Carbon-Neutral Electricity Sector in Uzbekistan 2050. The main idea is to diversify energy sources for electricity away from coal and gas.

In its first NDC, Turkmenistan did not provide a quantified emissions reduction target, but emphasized stabilization of emissions by 2030. In February 2023, Turkmenistan submitted its second NDC, aimed at achieving a 20% reduction in GHG emissions by 2030 relative to 2010 levels under a “business-as-usual” scenario. Turkmenistan has also announced adaptation actions to 2030, notably strengthening adaptive capacity, building resilience, and reducing vulnerability to climate change to achieve a sustainable economic development for the country. For the implementation of these adaptation actions to 2030, Turkmenistan demands international financial support of approximately USD 500 million. Turkmenistan does not have a fossil fuel phase-out policy or a net zero goal or strategy.

The Kyrgyz Republic adopted the Low-Carbon Development Strategy and the National Adaptation Policy. Although the regulatory and legal frameworks specified the exploitation of energy resources and the paths of energy transition, they do exist to some extent but are insufficient and are mostly of a declarative nature [78]. When conceiving and evaluating the possibilities for a sustainable energy future, it should be borne in mind that the Kyrgyz Republic is a low-income country [79]

and that the peaceful transfer of power took place for the first time after the elections in 2017, which makes it the most economically and politically unstable compared to other countries of the region [80]. A 31% poverty rate in the Kyrgyz Republic, which is the highest in the Central Asian region [81], and inadequate energy access for the population impose the need for finding a solution to this problem as one of the priorities of the energy transition, thus leaving less room for environmental concerns [82]. Furthermore, changes in the field of sustainable energy transition are also hampered by poor government institutional efficiency, high level of corruption, and an inefficient energy sector [83, 84]. The State Agency on Environmental Protection and Forestry developed a first draft of the “green economy” document—Concept for Long-term Development of the Kyrgyz Republic with Low Greenhouse Gas Emissions until 2050.

Tajikistan provides financial and regulatory incentives for the development of renewable energy sources, but the main limitations for investments in this sector are low tariffs for electricity and thermal energy and low collection of claims. In addition, the institutional capacities that should provide support are underdeveloped, and awareness and knowledge about the mechanisms for supporting the green transition and the benefits it brings to industry, companies, and citizens are low. Despite progress in developing energy efficiency policy and related legal and regulatory measures, especially in the construction sector, the potential for improving energy efficiency is untapped due to the failure to implement legislation. Currently, there is no visible progress in terms of sustainable energy transition in Tajikistan, and the main reason, in addition to the above, is the lack of adherence to environmental regulations [85]. Considering the demographic projections, inadequate regional cooperation in energy and water sharing appears to be a specific obstacle to achieving a sustainable transition [86]. The conflict between Tajikistan and Uzbekistan regarding the joint use of the new Rogun hydropower plant construction

remains unresolved, despite the intervention of donors [87]. All of the above indirectly indicates the unwillingness of the government and institutions to commit to a sustainable energy transition.

From the information provided, it is evident that there are specific differences among Central Asian countries, but they cannot be considered significant from the perspective of the green transition. Considered in general, and based on the analysis of several indicators (economic development, potential of renewable resources, progress in sustainable development), including the completeness of the legislative and regulatory framework, it can be said that Kazakhstan has made the most significant progress in the green transition process [88].

Conclusions

This paper aims to determine the status of green transition in Central Asian countries based on an analysis of key transition indicators from international statistical databases, a relatively small number of surveys and analyses, as well as policy analysis from official national documents that are rarely available in English or posted on the websites of referent institutions. In order to gain insight into the status and degree of coherence between the plans made by these countries and actual outcomes attained, a qualitative analysis of national sources in Russian was performed.

Although the region witnessed higher economic growth rates than the global average and an improvement in living standards between 2000 and 2020, it is still considered undeveloped, according to the Human Development Report. Due to the abundance of natural gas, oil, gold, uranium, and other resources in the region, economic growth relies heavily on the export of these natural resources. The economic structure is monolithic, with an underdeveloped industry, which makes it highly susceptible to fluctuations in raw material prices on world markets. Furthermore, Tajikistan, the Kyrgyz Republic, and Uzbekistan are among the top countries in the world in terms of the share of remittances inflow as a percentage of gross domestic product, which further indicates the dependent nature of their industries and the vulnerability of their economies.

The countries of the region are among the most energy-consuming countries in the world and the most vulnerable to climate change. Analysis of the transition indicators for the period 2000–2020 shows no evidence of significant changes towards a sustainable energy transition. All countries of the region (except Uzbekistan) have recorded an increase in carbon emissions, while carbon intensity of energy mix is almost the same. The only visible progress has been achieved in reduction of energy intensity. Notwithstanding the region's

significant capacities for renewable energy generation, their utilization remains insufficient. Besides the lack of regulatory framework and secondary regulation, some of the biggest barriers to deploying renewable energy are continued centralization and state ownership in the energy sector, with high subsidies for fossil fuels; and the lack of financial incentives, know-how, and qualified specialists in renewables. The research results show that a green transition in Central Asian countries is only declaratively accepted and poorly regulated by legislation. Even though some countries adopted relevant public policies, energy efficiency and climate change issues are only formally defined, while action plans and relevant regulation are still missing. Strategic planning of economic development that includes all related sectors (not only energy sector) and paying attention to socio-economic and environmental indicators of sustainable development are prerequisites for the successful implementation of the energy transition in these countries.

Central Asia's prospects in terms of green transition are significant, given that the region has large unused hydropower capacities (although disputes regarding the use of existing hydropower capacities have not yet been resolved) and potential for renewable energy sources. The sustainable energy transition may be accelerated by increasing the utilization of natural gas (as an environmentally friendly energy source) and by tapping into the largest deposits of uranium for the development of nuclear power capacity. However, the prospects for the green transition of Central Asian countries towards a more sustainable energy development should be assessed not solely based on their abundance of natural resources (not only energy resources) but also taking into account their willingness to enhance their legal and institutional framework, socio-economic progress, engagement in international politics, and geopolitical trends.

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Author contributions

SF and AAP prepared a draft of the study. AO participated in literature search. All authors read and approved the final manuscript.

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Competing interests

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