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ANALYSIS OF LOW CARBON AND RENEWABLE ENERGY RESOURCES IN CENTRAL ASIAN COUNTRIES

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Abstract

It is not secret that climate change is one of the main problems of today's economy. As a result of climate change, the amount of resources available in nature continues to decrease sharply, and as a negative result of this, the lack of resources, which is one of the main problems of the economy, is clearly manifested. This article analyzes the data on the capacity of renewable energy sources and low-carbon energy production capacity of a number of Central Asian countries. The countries of Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan have been studied.

Key words: Central Asia, Uzbekistan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, green economy, green energy, low carbon energy, renewable energy.

Introduction

At a global level, the percentage of people with access to electricity has been steadily increasing over the last few decades. In 1990, around 71% of the world's population had access; this has increased to 87% in 2016, not it should be more than 90% percent around the world. Progress has been fast. 1.26 billion got access to electricity for the first time in their lives between 2005 to 2016 [1]. Broken down to average daily change this means that on any average day in the last 11 years there were 314,770 people who got access to electricity for the first time in their lives. This figure is still unacceptably high - and gains in access are moving much too slow to reach our goal of universal access by 2030 [2]. In our research work we have fully given attention for central Asian countries electricity capacity, renewable energy recourses and low carbon energy recourses.

Today, the importance of the energy system is so high that if the stock of this type of goods is not sufficient, the economy of every country will be greatly damaged. For example, social security will decrease, disruptions will occur in the production sector, external economic and social sectors will be damaged, a number of disruptions will occur in the transport logistics sector, problems will arise in the military sector, health sector and a number of other sectors. On the other hand, it should not be forgotten that one of the most common types of electricity production today is thermal power plants. To obtain this type of electricity, we use coal, gas and a large amount of fuel and fuel products, which in turn leads to a decrease in natural resources, environmental degradation, and a decrease in the social status of the population. To make sure that everyone in the world has access to clean and safe energy, we need to understand energy consumption and its impacts around the world today and how this has changed over time.

Literature review

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Child and Breyer discussed the definition of transition and transformation in terms of energy systems, and they suggested that changes of physical forms be denoted as transformations, while changes to large socio-technical systems as transitions, when highlighting the ways that society motivates, facilitates, and benefits from the change on a higher level [3]. Energy transition is being discussed more extensively in many countries and regions of the world, not only due to the depletion of fossil fuels, but also because of the challenge of climate change and irreversible pollution [4]. **Jesse Richman, Nurullah Ayyılmaz** scientists "Can the US and Europe contain Russian power in the European energy market? A game theoretical approach"[4]. In doing so, the scientists analyzed Russia's role in the Euro energy market and the attitudes of its competitors.

In Europe many scholars have done many researches in this field such as **Dr Vaughan Beck** (Australia – the Australian Academy of Technological Sciences and Engineering), **Professor Robert Evans** (Canada – the Canadian Academy of Engineering), **Professor John Loughhead** (UK – Royal Academy of Engineering) and so on, and they collected their researches "Opportunities for Low-Carbon Energy Technologies for Electricity Generation to 2050" energy report [2]. Inside them they focused on every part of the low carbon energy production sector, financial, economical, and others.

Methodology

The research sample consists of a total of 5 Central Asian countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan. The policy review was conducted by reviewing available official documents and reports. The most comprehensive data were obtained by reviewing energy conditions of central Asia and were supplemented by observations from additional scientific literature and reports. Measurement of data statistical methods and econometrical analysis were used for data processing. Quantitative analysis includes mostly series for the period 2010–2020, but in some cases the data for 2021 is also used. To make a comparison with central Asian countries in energy supply we take these indicators: low carbon energy, renewable energy, energy consumption per capita, energy rate in GDP and others. The indicator GDP per capita PPP (current international USD) was obtained by inspecting the database of the World Bank [3], while other indicators were obtained by inspecting the database of the International Energy Agency [5].

Results and discussions

Some Central Asian countries used to be the members of the USSR, and after its disintegration they embarked on the path of independence. Nowadays, each country defined certain policies for the energy sector development, which is the subject of this part of the analysis, where 2020 is the last year for which the sources were considered.

Kazakhstan

The Republic of Kazakhstan has embarked on the energy transition from the fossil-based to low carbon power. Coal is the dominant source of energy in the country, accounting for 64.7% of total projected generation and 74.0% of thermal generation in 2019 [5]. The government is seeking to diversify Kazakhstan's energy mix and the National Green Growth Plan envisages the following (optimistic) breakdown by 2030: 49.0% coal, 21.0% gas, 10.0% hydropower and 8.0% nuclear, alongside a sizeable renewables element [6]. However, we predict that the relative contribution of coal will fall at a slower pace than targeted by the government, such that it still accounts for 64.9% of total electricity generation and 74.0% of thermal generation in 2028 [7]. By

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2050, the government anticipates that non-thermal sources will generate at least half of Kazakhstan's energy needs [8]. This plan requires the start of a domestic nuclear energy program and significant growth in non-hydro renewables. Kazakhstan will remain open to foreign investment as a means to import the capital and expertise to realize its objectives, although investor uncertainty about the operating environment will further militate against the government achieving its targets. In this article we have paid attention to the source of fossil based energy production such coal, gas, oil and renewable and low carbon energy production sources in central Asian countries.

Fossil fuel

For most of the countries in the world energy from coal is common types of electricity production. Kazakhstan is also one of them. In the first table we have tried to illustrate annual electricity production, annual per capita electricity production and share of total electricity production for Kazakhstan from 2010 to 2022 (Table 1) [11].

Table 1. Fossil fuel energy production from 2010 to 2022 in Kazakhstan.

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2010	75	4,488	90
2011	79	4,666	91
2012	83	4,853	92
2013	85	4,893	92
2014	86	4,910	91
2015	82	4,609	90
2016	83	4,572	87
2017	91	4,995	88
2018	96	5,198	90
2019	95	5,086	90
2020	97	5,095	89
2021	102	5,329	89
2022	100	5,155	89

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

It is obvious from the table that electricity production is main one for this country. The reason for this mini conclusion that every year from 2010 to 2022 its percentage in the whole electricity production is more than 60 percent. In the last three years its percentage is decreasing steadily, because low carbon energy and renewable energy production is increasing in this country. Annual electricity production from coal is measured in TWh, I should mention that 1 TWh (terawatt hours) equal to 1,000,000 megawatt-hours (MWh) or 1,000,000,000 kilowatt-hours (kWh). To compare annual production of electricity from coal to per capita, we should change terawatt to kilowatt, and after that we can easily compare them each other. The highest per capita electricity production we can see in 2010, 2011, 2018 years from 2019 till 2022 its rate was decreasing steadily. The reason for this also an increase in the production of electricity from low carbon energy and renewable energy.

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Low carbon and renewable energy

The country has taken steps to attract greater investment into the renewable energy segment in recent years - introducing a 15-year feed-in-tariff (FiT) mechanism in 2013 - and there are plans to open up the power and energy sectors to greater numbers of private investors. The main focus for the renewables sector is wind and solar power (Table 2) [11]. Kazakhstan is very rich in wind potential, with around 50.0% of the country's territory having average wind speeds of 4-5m/sec at a height of 30m. The wind potential of Kazakhstan is 1.8trn kWh per year, close to 10 times Kazakhstan's current energy consumption, according to UN estimates. Solar also has great potential given the number of sunny hours per year - typically between 2,200 and 3,000 - implying a capacity of 1,300-1,800kW/sqm per year. In the second table we can the low carbon and renewable energy production potential of Kazakhstan. Low-carbon electricity is the sum of electricity generation from nuclear and renewable sources. Renewable sources include hydropower, solar, wind, geothermal, bioenergy, wave and tidal. In Kazakhstan there in no any kind of nuclear energy so we do not pay attention for this type of energy production.

Table 2. Low carbon energy and renewable energy production in Kazakhstan from 2010 to 2022

Years	Nuclear power	Hydropower (in TWh)	Solar (in TWh)	Wind (in TWh)	Low carbon and renewable energy per capita (in kWh)	Shared of total electricity (in percentage)
2010	-	8,02	0	0	8	10
2011	-	7,88	0	0	8	9
2012	-	7,62	0	0	8	8
2013	-	7,73	0	0	8	8
2014	-	8,26	0	0,01	8	9
2015	-	9,72	0,05	0,13	9	13
2016	-	11,62	0,09	0,27	12	11
2017	-	11,21	0,09	0,34	12	10
2018	-	10,38	0,14	0,39	11	10
2019	-	9,99	0,39	0,71	11	11
2020	-	9,66	1,24	1,03	12	11
2021	-	9,09	1,29	1,67	12	11
2022	-	9,10	1,41	2,28	13	11

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

Hydropower accounts for approximately 12.3% of Kazakhstan's total generating capacity. Kazakhstan has abundant hydro resources, which are mainly concentrated in the eastern and southern parts of the country on the Irtysh, Ili and Syrdarya rivers (73 % of the total capacity of hydro resources). Hydropower plants on the Irtysh River constitutes of the Bukhtyrma (750MW), Shulbinsk (702MW) and Ust-Kamenogorsk (315MW), the Kapshagai (364MW) plant on the Ili River, and the Shardarinskaya(104MW) plant on the Syrdarya River [9]. Kazakhstan is rich in wind energy resources. In some regions, the average wind speed at an altitude of 15 m is 27-36 m / s. there are at least 10 areas with a large wind potential with an average wind speed of 8 -10 m/s.

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The most significant are the wind energy resources of the Dzungarian Gate (17,000 kWh / m2). Other promising areas include Yerementau (Akmola region), Fort Shevchenko (Caspian Sea coast), Korda (Zhambyl region) [10].

The potential of solar energy in Kazakhstan is estimated at 2.5 billion kWh per year, which corresponds to an area of about 10 km2 of solar cells with a total efficiency of 16%. The average efficiency of modern solar panels varies in the range of 15-25%. Solar energy can be widely used in two-thirds of the territory of the Republic of Kazakhstan. In the southern regions, the duration of solar radiation is from 2,800 to 3,000 hours per year, and the annual consumption of solar energy is from 1,280 to 1,870 kWh per 1 m2. Moreover, in June, the amount of energy per 1 m2 on the horizontal surface ranges from 6.4 to 7.5 kWh per day, which makes the South Kazakhstan, Kyzylorda and Aral regions extremely favorable to produce solar energy. According to the Strategic development plan of the Republic of Kazakhstan and the Concept of transition to a "green economy" it is planned to put into operation about 28 solar power plants by the end of 2020 [11].

Tajikistan

At Tajikistan, the average electricity available amounts to less than 4 hours daily during winter. Tajikistan has enormous hydro power potential as it possesses 4% of the world's hydro power resources and 53% of Central Asia's resources. Yet these resources remain to be sufficiently developed. About 94% of electricity generating capacity is hydroelectric, but only an estimated 5% of its potential is in use.

Fossil fuel

Fossil fuel is also main types of electricity for Tajikistan. In the following table three we have paid attention to the electricity production from fossil fuel, fossil fuel contains coal, oil, and gas from 2010 to 2022 (Table 3) [11].

Table 3. Fossil fuel energy production from 2010 to 2022 in Tajikistan

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2010	0,1	4	0,20
2011	0,1	5	0,25
2012	0,1	9	0,40
2013	0,1	5	0,25
2014	0,2	18	1
2015	0,2	18	0,90
2016	0,6	64	3,29
2017	0,9	103	5,15
2018	1,3	139	6,52
2019	1,4	152	6,90
2020	1,6	170	8,20
2021	2	177	8,80
2022	-	-	-

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

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From the table there is no doubt that fossil fuel is not the main source of electricity production, the reason for this that low carbon energy and renewable energy is the main source of electricity production. The highest percentage of fossil fuel energy production is 2% in the total production of energy in Tajikistan.

Low carbon and renewable energy

We have mentioned before that main source of electricity production in Tajikistan is low carbon and renewable energy. In the following table 4 [11], we have paid attention to the low carbon and renewable energy production in Tajikistan.

Table 4. Low carbon energy and renewable energy production in Tajikistan from 2010 to 2022

Years	Nuclear power	Hydropower (in TWh)	Solar (in TWh)	Wind (in TWh)	Low carbon and renewable energy per capita (in kWh)	Shared of total electricity (in percentage)
2010	-	16,24	0	0	2,131	99,82
2011	-	16,04	0	0	2,060	99,75
2012	-	16,73	0	0	2,103	99,58
2013	-	16,90	0	0	2,077	99,76
2014	-	15,84	0	0	1,902	99,06
2015	-	16,83	0	0	1,974	99,12
2016	-	16,47	0	0	1,888	99,71
2017	-	16,96	0	0	1,900	94,85
2018	-	18,21	0	0	1,995	93,48
2019	-	19,17	0	0	2,053	93,10
2020	-	18,11	0	0	1,898	91,79
2021	-	18,00	0	0	1,846	91,23
2022	-	-	-	-	-	-

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

Tajikistan is one of the focus countries of the EU4 Energy programme [12], which is being implemented by the IEA and the European Union along with the Energy Community Secretariat and the Energy Charter Secretariat. The Republic of Tajikistan is a landlocked country situated in the southeast of Central Asia. The government also plans to develop energy sources other than large hydro to diversify the fuel mix and reduce volatility in electricity generation. Having sizeable coal deposits/reserves and a coal production history of more than a century, the government has turned to coal as an ultimate fuel in resolving severe electricity shortages in winter months, when water levels are too low for electricity production. Production of coal in 2020 reached 2.1 Mt, which is a tenfold rise from 2010. Coal has rapidly become a key energy source in Tajikistan (26.3% of total energy supply (TES) in 2020). Barqi-Tojik constructed a new coal-fired power plant, Dushanbe-2 (400 MW capacity), and a new TPP is planned to be built by 2025 in Zarafshon. Over 130 MW of small hydro had been developed by the end of 2014, and other plans include

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converting heat generation plants from gas to coal and rehabilitating existing TPPs to improve efficiency. Tajikistan's primary energy production amounted to 2.5 Mtoe in 2020. Domestic energy production mainly consists of hydro (62% of production in 2020) and coal (37%). Hydro generation has increased in recent years (+13% since 2015) as a result of capacity additions. Coal mining has increased from negligible quantities in 2010 to over 2 Mt (1.2 Mtoe) in 2019. Overall self-sufficiency has grown from around 60% of the TES in the early 2010s to almost 75% in 2019 [13].

Kyrgyzstan

In 2016, there was approximately 40 MW of small hydro capacity. The National Energy Program and the Strategy for Fuel and Energy Sector Development (covering 2010-25) [15] are the key policies for sustainable energy development. The rapid expansion of renewables, especially hydro, is a priority for energy sector development, and the Strategy supports the construction of approximately 100 small hydroelectric plants with total capacity of 180 MW.

Fossil fuel

After Kyrgyzstan gained its independence, residential power consumption rose significantly due to intensive use of electricity for heating and cooking. In November 2014, new electricity tariffs were approved based on a 700-kWh monthly threshold for residential electricity consumers (700 kWh is the level of power consumption that can be satisfied through domestic power generation). Above this threshold, residential consumers are charged a higher tariff (assessed for domestic power generation) plus the cost of imported power during the winter months. This threshold and the new tariffs provide incentives for consumers to conserve energy, especially in winter, and to adopt alternative fuels when it is economically efficient (coal, for example). In the table 5 [11], fossil fuel energy production from 2010 to 2022 in Kyrgyzstan is demonstrated.

Table 5. Fossil fuel energy production from 2010 to 2022 in Kyrgyzstan

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2010	0,8	170	7,80
2011	0,9	173	6,42
2012	0,8	165	6,21
2013	0,7	150	6,20
2014	1	206	8,36
2015	1,7	306	14,14
2016	1,6	276	12,73
2017	1,3	201	8,04
2018	1,2	182	7,39
2019	1,2	179	7,61
2020	1,4	213	8,47
2021	1,5	224	10,10
2022	-	-	-

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

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A more reliable supply of gas and implementation of Gazprom Kyrgyzstan's investment programme to improve the gas grid will further encourage switching from electricity to gas and coal. Under the National Strategy for Sustainable Development for 2018-2040 [14], energy efficiency technologies must be applied in all new construction and the government plans to implement large-scale programmes on energy-efficient reconstruction of old residential and non-residential buildings, and to introduce energy efficiency passports for all buildings.

From the table above it is obvious that fossil fuel is not the main source to produce electricity in Kyrgyzstan. Annual electricity production from the fossil fuel is decreasing year by year in the late 5 years. Electricity production in per capita also decreasing year by year from 2010 to 2022, in 2021 it was increased but not dramatically.

Low carbon and renewable energy

The Law on Renewable Energy adopted at the end of 2008 established an important framework for renewable energy development in general, and for small HPPs in particular. It provides a number of incentives and preferences, such as exemption from customs duties on equipment import and export, relief from licensing for generation, the right to sell output to consumers under commercial agreements, and guaranteed purchase of renewable energy output by the distribution company. Renewable energy developers also have a multiplying coefficient of 1.3 for the feed-in tariff (for all renewable sources: hydro, wind, solar, biomass and geothermal). The law also guarantees non-discriminatory access of renewable energy output to the grid and obligates the National Grid and distribution companies to ensure unobstructed transit of renewable energy to consumers. In the table 6 [11], Low carbon energy and renewable energy production in Kyrgyzstan from 2010 to 2022 has been illustrated.

Table 6. Low carbon energy and renewable energy production in Kyrgyzstan from 2010 to 2022

Years	Nuclear power	Hydropower (in TWh)	Solar (in TWh)	Wind (in TWh)	Low carbon and renewable energy per capita (in kWh)	Shared of total electricity (in percentage)
2010	-	11	-	-	2,006	92,20
2011	-	14	-	-	2,521	93,58
2012	-	14,04	-	-	2,493	93,79
2013	-	13	-	-	2,273	93,80
2014	-	13,16	-	-	2,263	91,64
2015	-	10,99	-	-	1,858	85,86
2016	-	11,38	-	-	1,891	87,27
2017	-	14,06	-	-	2,297	91,96
2018	-	14,17	-	-	2,277	92,61
2019	-	13,71	-	-	2,168	92,39
2020	-	14,80	-	-	2,302	91,58
2021	-	13	-	-	1,992	89,90
2022	-	-	-	-	-	-

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

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There are currently no waste-to-energy projects or initiatives. Municipalities of large cities have been considering building plants for converting non-recyclable waste materials into electricity and heat, but no plans have yet been fully developed or implemented. Kyrgyzstan's geographic location and climatic conditions are quite favorable for the broader development of solar energy, evident in solar radiation maps. Annual specific power generation by photoelectrical equipment has a potential 300 kilowatt hours per square meter (kWh/m2), and annual specific productivity of solar hot water supply could be up to 750 kWh/m2 (heat). These figures assume the availability of increasingly inexpensive photoelectrical converters, modules and flat solar collectors, as well as the necessary scientific-technical capacity. In Kyrgyzstan's predominantly mountainous terrain, winds of constant direction and strength sufficient for power generation can only be found in remote and sparsely populated areas. Analysis of instrumental observations at meteorological stations reveals that the actual average annual wind speed is much lower than 5 metres per second (m/s) (only at one weather station does it exceed 5 m/s, and that is for two months per year only). As construction of wind power plants is considered feasible from an average annual wind speed of 8 m/s, those areas with average speed of 5 m/s or less are not suitable for wind turbine installation. The potential for wind energy is therefore very low in populated residential areas, and the areas where wind energy could be economically viable are far from consumer centers and difficult to access. The main share of renewable energy in production is hydropower. Its trends are some have fluctuated, there is no exact increase or decrease. Hydropower energy production is somehow the same average 13 or 14 TWh, in per capita it is average 2000 kWh.

Turkmenistan

The electrification rate in Turkmenistan is 99.6%. Electricity is mostly produced in 8 thermal power plants with an installed capacity of 3.3 GW. Electricity consumption by sector is the following: agriculture and forestry 31.8%, industry 36%, transport 2.6%, and residential 21%. Demand for renewable energy sources in Turkmenistan is practically inexistent. Turkmenistan has relatively low potential for bio energies, hydro power, and geothermal energy. While it does have tremendous wind and solar power with 300 sunny days per year (equaling 2,00 kW/m²/yr) and wind potential equal to the country's fossil fuel potential, its wealth of oil and gas overshadow these potentials.

Fossil fuel

Turkmenistan has the world's fourth-largest reserves of natural gas and is one of the region's key suppliers of this fuel. The devastating effects of climate change felt most keenly in Central Asia are spreading desertification, water scarcity, heat waves, and droughts. Official Ashgabat plans to take several measures, according to experts at the regional finance institute. The first measure under consideration is to improve energy efficiency in the production, consumption, and transportation of hydrocarbons, including preventing methane leaks. Second, Turkmenistan has vast potential for developing renewable energy such as solar and wind power, so investments to diversify sources could bring gains. Third, in fostering technological advances, the country plans to explore the development of green hydrogen by learning and adopting modern practices used in developed countries. It also plans to introduce various carbon capture, use, and storage technologies to reduce harmful emissions into the atmosphere. In the table 7 [11], Fossil fuel energy production from 2010 to 2022 in Turkmenistan has been illuminated.

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Table 7. Fossil fuel energy production from 2010 to 2022 in Turkmenistan

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2010	16	2973	100
2011	16	3020	100
2012	17	3056	100
2013	18	3191	100
2014	19	3387	100
2015	21	3673	100
2016	21	3609	100
2017	21	3549	100
2018	21	3492	100
2019	21	3439	100
2020	20	3217	100
2021	21	3374	100
2022	-	-	-

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

From the table it is obvious that 100% electricity production is based on the fossil fuel energy. Annual electricity production from fossil fuel and per capita electricity production from fossil fuel have increased steadily from 2010 till 2021 respectively.

Turkmenistan, possessing one of the largest energy potential in the world, strives to establishment of stable structure of the global energy security, which is built on the principles of justice, balance of interests of both supplying countries and transit countries and consumers. Energy cooperation, based on beneficial and long-term partnership, formed on the basis of common principles and rules, is a condition of steadfast development of the world community. Energy is life which has been endangered because of power politics and scarcity of energy resources in the region as well as around the globe. Energy fuels development and Turkmenistan implements an energy policy of easy and smooth supply of energy resources to consumers, as well as export of electricity to foreign consumers. It has the world's fourth largest estimated reserves of natural gas. Turkmenistan strives to give its unlimited energy resource potential to the disposal of the mankind, realizing the energy policy based on the principles of combined modernization of fuel and energy complex and diversification of energy supplies to the world markets. Energy policy of Turkmenistan is based on diversified operationalization and channelization of energy resources, efficiency and saving of energy, optimal use of energy resources, energy security, investments, energy diplomacy, innovations and the last but not the least development of renewable or green energy resources. Moreover, increasing internal/national production capacity to meet external demands, diversifying energy export routes, increasing export capacity, securing energy transportation and networks to external markets are also salient features of its energy policy. For the further development of national energy resources and production channels, the government of Turkmenistan will make investments of 240 billion manats in oil and gas sector. The Government of Turkmenistan announced total existing generation capacity equals 5,432,4 megawatt (MW). In 2016, Turkmenistan produced more than 24 billion kWh. Turkmenistan has ambitious plans to bring power generation capacity to about 26 billion kWh by 2020 and to 35 billion kWh by 2030

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by upgrading existing power stations and building new ones. The country has announced plans to build 14 new gas turbine power stations with a total capacity of 4,000 megawatts by 2020. Turkmenistan exports approximately 65bcm (Billion cubic metres) gas to China. It exports 10bcm gas to Russia. It supplies more than 50bcm gas to Iran too. Dream Gas Pipeline in shape of TAPI would export up to33bcm and Turkmenistan-Europe gas pipeline exports 30bcm through the Trans-Caspian Gas pipeline.

Low carbon and renewable energy

Today, it is no secret that Turkmenistan ranks among the world's most developed countries in terms of natural resources. Therefore, due to the lack of demand for low-carbon and renewable energies, the production of this type of electricity has not been established in Tajikistan. That's why, finding information in terms of low carbon and renewable energy production is somehow hard.

Uzbekistan

Uzbekistan has been implementing large-scale reforms in recent years to strengthen its energy industry. Problems are associated with high wear and tear on equipment as well as with the slow pace of infrastructure updates, faulty equipment operations, inadequate installations, and both gas pipelines and power lines that have exceeded their service life. The country's unstable financial situation and inadequate introduction of resource- and energy-saving technologies have raised technological losses and made fuel and energy resource supply interruptions more frequent. In Uzbekistan fossil fuel is main source to produce electricity.

Fossil fuel

Uzbekistan is implementing comprehensive measures to deepen structural reforms, modernize and diversify basic sectors of the economy, and balance the socioeconomic development of its territories. Presidential Decree No. PP-4477 of 4 October 2019 approved the Strategy for the Transition of the Republic of Uzbekistan to the Green Economy for the Period 2019-2030 [15].

Today Uzbekistan's electricity production capacity from the fossil fuels is given in the following table seven. The table 9 [11], includes the information about the electricity production from fossil fuels (such as coal, gas, oil) from 2010 to 2022.

Table 9. Fossil fuel energy production from 2010 to 2022 in Uzbekistan

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2010	41	1,438	84
2011	44	1,524	89
2012	44	1,476	87
2013	46	1,534	89
2014	47	1,534	89
2015	48	1,536	87
2016	49	1,550	87
2017	50	1,556	86
2018	54	1,651	90
2019	54	1,627	89
2020	51	1,519	90

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2021	54	1,590	92
2022	-	-	-

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

Development of annual production of fossil fuel in Uzbekistan and forecast values for the following periods is important in working out prospects for further development of the industry. For this, it is necessary to analyze the characteristics of the time series of the forecasted indicator.

Low carbon and renewable energy

As global GDP and population growth have aggravated environmental problems and raised awareness of energy resource limitations, many countries have made the transition to sustainable development their main goal. Intergovernmental Panel on Climate Change (IPCC) research shows that raising the CO2 price to USD 50 per tonne of carbon dioxide (/tCO2) emitted into the atmosphere and expanding the use of RESs would help reduce CO2 emissions 38% by 2030, and 70% by 2050 [16].

In 2018, Uzbekistan ratified the Paris Agreement and adopted a national commitment to reduce GHG emissions per unit of GDP by 10% of the 2010 level by 2030 [17]. According to the Strategy on the Transition of the Republic of Uzbekistan to the "Green" Economy for the Period 2019-2030, Uzbekistan aims to increase the share of RESs in total electricity generation to more than 25% by 2030 [17]. It also plans to double its energy efficiency indicator, reduce the carbon intensity of GDP, and provide the entire population and all economic sectors with access to modern, inexpensive and reliable energy.

Uzbekistan's considerable RES potential could spur significant development of a green, environmentally friendly economy. The country's total RES potential is 117 984 Mtoe, while its technical potential is 179.3 Mtoe.

The bulk of this potential lies in solar energy (total potential of 51 Gtoe and technical potential of 177 Mtoe). In fact, solar energy's technical potential is almost four times the country's primary energy consumption. Its favorable climate and geographical location would allow Uzbekistan to use solar energy for a wide range of industrial purposes. Wind energy potential totals 2.2 Mtoe, with 19% technical development possible. Although total geothermal energy potential (67 Gtoe) exceeds that of solar, the underdevelopment of simple and cost-effective technologies to exploit this type of energy limits technical development to only 0.3 Mtoe.

In the following table 11 [11], low carbon and renewable energy production information is given from 2010 to 2022. Renewable energy and low carbon energy are not main types of energy production for Uzbekistan, but it is time to change it.

Table 11. Low carbon energy and renewable energy production in Uzbekistan from 2010 to 2022

Years	Nuclear power	Hydropower (in TWh)	Solar (in TWh)	Wind (in TWh)	Low carbon and renewable energy per capital (in kWh)	Shared of total electricity (in percentage)
2010	-	8,11	0	-	283	17
2011	-	5,65	0	-	194	11
2012	-	6,59	0	-	223	13

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2013	-	5,65	0	-	189	11
2014	-	6,01	0	-	197	11
2015	-	7,00	0	-	226	13
2016	-	7,25	0	-	230	13
2017	-	8,34	0,01	-	261	14
2018	-	5,84	0,01	-	180	10
2019	-	6,46	0,01	-	196	11
2020	-	5,00	0,01	-	149	9
2021	-	5,00	0,01	-	147	8
2022	-	-	0,01	-	-	-

Source: Hannah Ritchie, Max Roser and Pablo Rosado. Energy, Our world in one data. **https://ourworldindata.org/team**

While Uzbekistan's annual electricity production amounted to 54.2 billion kWh in 1991, it had dropped to 45.4 billion kWh by 1996 because the power units at its largest power plants had become obsolete. Electricity production rose steadily between 1996 and 2018, however, as a result of modernization and commissioning of new power units. Uzbekistan's total electricity generation capacity is 14.1 GW, with TPPs accounting for 85.8%. With GDP and population growth, the country's electricity demand is bound to increase. Production is therefore forecast to rise to 84.9 billion kWh by 2025 – 40% above the 2018 level. Electricity generation capacity is expected to expand 2.5 times to double annual production by 2030 [17].

The development of forecast values of the hydropower indicator for the next period is important in working out the prospects for further development of the sector. For this, it is necessary to analyze the characteristics of the time series of the forecasted indicator. In the figure 6, changing trends of hydropower of Uzbekistan is shown.

Conclusion and recommendations

Today, many countries' renewable energy goals include reducing GHG emissions, increasing the share of renewable energy in final energy consumption, and meeting growing demand for energy. Uzbekistan is also developing objectives to promote renewable energy and increase its share in the overall energy balance. It particularly aims to increase the share of renewable energy in total electricity production from 10-12% in 2018 to 20% by 2025, including raising the HPP portion from 10-12% to 15.8%, solar energy from 1.95% to 2.3% and wind energy from 1.36% to 1.6% [18].

As in other developing countries, a number of factors continue to hinder renewable energy development in Uzbekistan.

First, the high cost of producing renewable energy and its limited generating capacity compared with traditional energy sources, as well as the low cost of traditional energy sources compared with other countries.

Second, there are no specific financial support mechanisms (tariffs and taxes) that stimulate RES use. The legal framework for economic mechanisms promoting RES use is inadequate.

Third, progressive techniques and technologies based on modern control systems are not sufficiently developed. One of the main reasons for the low rate of RES development is the

technical imperfection of these types of energy production technologies. Plus, short-term energy system profitability is low.

Fourth, as in many other developing countries, public awareness of modern forms of energy – especially renewable energy – is lacking.

Fifth, innovative renewable energy technologies are being developed too rapidly for Uzbekistan to keep up. For example, solar panels made of semiconductor silicon were quickly replaced by photoelectric panels made of amorphous silicon, and then by flexible solar cells. Because there is no local renewable energy technology manufacturing in Uzbekistan, purchase, installation and maintenance costs remain high. Rapid development of the industry requires that outdated technologies be quickly replaced with new ones.

Sixth, nuclear power influences the scale of renewable energy use and hampers development of the energy sector.

Above, some shortcomings of the central Asian countries' energy production are mentioned. To tackle them we should implement these innovations or changes in central Asian countries. **Firstly,** we should create well developed energy logistics system in central Asian countries. With the help of these new innovative system energy outlook will increase in all countries in central Asia. **Secondly**, it is necessary to increase the number of photoelectric power stations in all the countries of Central Asia, which are among the sunny countries, and as a result, it is necessary to strengthen the field of energy production to European countries. **Thirdly,** in the countries of Central Asia, it is necessary to establish the sector of obtaining electricity through the processing of waste, which is not yet developed, in which the systems existing in Korea and Germany should be used.

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