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LOW CARBON AND RENEWABLE ENERGY RESOURCES IN CENTRAL ASIAN COUNTRIES

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Abstract. Today, all the countries of the world are focusing their attention on the reforms to be implemented in order to transition to a green economy and a sustainable business form. The main reason for this is the limitation of natural resources and the unlimited material needs of mankind. A number of reforms in this field are being carried out in the Central Asian countries, like every other country. Regarding the development of electricity, which is one of the most important commodities today, many projects and targeted plans are being implemented to transition from traditional electricity generation to low-carbon, renewable energy sources. The main reasons for this are the reduction of natural resources, the negative change in climate from year to year, and the increasing importance of energy reserves. This sector can be represented by the transition to a green economy, the strengthening of the renewable and low-carbon energy sector.

Key words. Central Asia, Uzbekistan, green economy, sustainability, green energy, low carbon energy, renewable energy, energy, fossil fuels.

Introduction:

The close and high relationship between production growth and energy consumption growth in the economy refers to the dependence of the economy on energy [1]. Thus, the economy is not only sensitive to energy supply and price shocks, but any initiative to conserve energy can have an impact on the performance of the economy. Electricity is a crucial for poverty alleviation, economic growth and improved living standards. We should not forget about one thing that 13% of the world do not have access to electricity. This is very high percentage in terms of numbers it is more than 9 million people around the world do not have electricity access. Measuring the share of people with electricity access is therefore an important social and economic indicator. There is no universally-adopted definition of what 'access to electricity' means. However, most definitions are aligned to the delivery of electricity, safe cooking facilities and a required minimum level of consumption. 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 [2]. 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. This is particularly true for Sub-Saharan Africa - despite the share of the population with electricity rising steadily, population growth meant that the total number of people without access was on the rise until 2016. Accelerated progress will be needed to ensure this number now continues to fall. In our research work we have fully given attention for central Asian countries electricity capacity, renewable energy recourses and low carbon energy recourses.

It is possible to include the Central Asian countries among the countries with a lot of natural resources, but the biggest problems facing the world economy today, the reduction of resource reserves, climate change, and demographic growth affect the Central Asian countries with their negative consequences didn't miss either. Among the biggest and social tasks facing every country today, we can mention the large-scale reforms aimed at transitioning to a green economy and strengthening sustainable business. Also, the importance of increasing the weight of low-carbon energy and renewable energy in the general energy system, which are the largest branches of the green economy, is considered very important today.

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.

Low carbon energy and renewable energy resources contain following sources to produce electricity. Low carbon energy is the sum of nuclear and renewable energy sources. This is based on primary energy equivalents, rather than final electricity use. Renewables is the sum of energy from hydropower, wind, solar, geothermal, wave and tidal, and bioenergy. Traditional way of producing energy is Electricity generation from coal, oil and gas sources combined. It is time for all countries to change these types of production for law carbon energy and renewable energy resources. In this article, we have tried to discuss energy resources of central Asian countries and Uzbekistan. For the next 5 years, there are econometric models to prognose the level of low carbon energy and renewable energy resources.

The main objectives of the research work are discussing the central Asian countries energy capacity, to measure it we have paid attention to these sides of the energy production:

1. Low carbon energy production capacity in central Asian countries and their policies;
2. A brief information about the capacity of producing renewable energy resources in central Asian countries and their future trends;
3. A brief information about the production capacity of electricity from fossil fuels such a coal, oil, gas.

Research purpose:

This research work has been done in the form of IMRAD model. Research work contains the following chapters.

Abstract;
Key words;
Introduction;
Research purpose;
Literature review;
Methodology;
Results and discussion;
Conclusion and recommendations.

Literature review:

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"[5]. 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 [6]. Inside them they focused on every part of the low carbon energy production sector, financial, economical, and others.

Solar power generation is characterized by variability and uncertainty. Business decisions considering where best to install photovoltaic (PV) arrays rely on historical solar irradiation data, which measure the solar energy that reaches the earth's surface over a long-term period. This usable energy varies according to latitude, elevation, season, and climate. The value of more short-term, namely day-ahead, solar power forecasting is discussed in **Brancucci** et al.'s 2017 paper [7], and indicates that such forecasting can lead to a reduction in overall solar energy generation costs. The paper discusses the 'duck curve', in which solar power generation is observed to be highest during the middle of the day, and can account for a greater share of electrical power generation; however, more conventional power generation methods are required to meet demand during the downward (during sunrise) and upward (during sunset) sloping sections of the curve.

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 2000–2020, 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 [2], while other indicators were obtained by inspecting the database of the International Energy Agency [8].

By applying the selected explorative methods, the historical trend, the correlation of the selected indicators, as well as the assessment of the reliability of the applied methods are determined (with the aim of gaining insight into methodological correctness).

Results and discussions:

All Central Asian countries used to be the members of the USSR, and after its disintegration they embarked on the path of independence. During the 1990s, they were hit by crises in all areas, energy system was not good in all central Asian countries at that time, but year by year they are getting well, followed by gradual consolidation when each country chose its own path of development. To this end, 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.

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 [2]. 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 [9]. 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 [10]. By 2050, the government anticipates that non-thermal sources will generate at least half of Kazakhstan's energy needs [10]. 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 2000 to 2022 (Table 1) [11].

Table 1

Fossil fuel energy production from 2000 to 2022 in Kazakhstan.

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2000	44	2,895	85
2001	47	3,095	85
2002	49	3,223	85
2003	55	3,583	86
2004	59	3,794	88
2005	60	3,826	88
2006	64	4,038	89
2007	68	4,276	89
2008	73	4,500	91
2009	72	4,380	91
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 2000 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.

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 2000 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)
2000	-	7,53	0	0	8	15
2001	-	8,08	0	0	8	15
2002	-	8,89	0	0	9	15
2003	-	8,62	0	0	9	13
2004	-	8,06	0	0	8	12
2005	-	7,86	0	0	8	12
2006	-	7,77	0	0	8	11
2007	-	8,17	0	0	8	11
2008	-	7,46	0	0	7	9
2009	-	6,88	0	0	7	9
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

From the table it is obvious that there is no nuclear energy production in Kazakhstan. Low carbon energy includes nuclear energy and renewable energy. Renewable energy includes the following sources itself such as solar, wind, hydropower, biomass and waste, geothermal and wave and tidal. Hydropower is the main source of renewable energy production solar and wind are after that, from 2014 these types of renewable energy was begun to produce.

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 [10]. 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. 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 [12].

Tajikistan:

After the end of the Soviet Union, electricity subsidies were terminated and the following energy demand gap was predominantly filled by local biomass resources, such as coal and wood, resulting in increased deforestation and pollution. In certain areas, 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 2000 to 2022 (Table 3) [11].

Table 3

Fossil fuel energy production from 2000 to 2022 in Tajikistan

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2000	0,2	33	1,50
2001	0,2	27	1,20
2002	0,2	20	0,90
2003	0,2	24	1
2004	0,2	21	0,90
2005	0,2	17	0,70
2006	0,3	33	1,40
2007	0,4	53	2,20
2008	0,3	48	2
2009	0,2	29	1,40
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

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 2000 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)
2000	-	13,77	0	0	2,195	98,50
2001	-	14,06	0	0	2,194	98,81
2002	-	15,01	0	0	2,294	99,14
2003	-	16,17	0	0	2,423	99,02
2004	-	16,18	0	0	2,379	99,14
2005	-	16,80	0	0	2,425	99,29
2006	-	16,53	0	0	2,342	98,16
2007	-	16,94	0	0	2,357	97,81
2008	-	16,64	0	0	2,272	97,84
2009	-	16,74	0	0	2,107	98,62
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

Table illustrates that low carbon energy and renewable energy is the main source of electricity production for Tajikistan, but their share is not so high for like other countries in central Asian countries. From the table it is obvious that the main source for renewable energy is Hydropower, year by year its share of total energy is increasing, whereas year by year its share in per capita in Tajikistan is decreasing, this means that populations is increasing more than electricity supply in Tajikistan. We should pay attention to the total share of low carbon and renewable electricity production in total electricity production. It used to be nearly 100%, but year by year its percentage is decreasing, this does not mean these types of electricity production is decreasing, whereas it means population is increasing.

Tajikistan is one of the focus countries of the EU4 Energy programme [13], 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 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 2000s to almost 75% in 2019 [10].

Kyrgyzstan:

Kyrgyzstan has considerable untapped renewable energy potential. Existing renewable energy consists of large HPPs, which account for 30% of total energy supply, but only 10% of hydropower potential has been developed. Opportunities to develop decentralized renewable energy technologies are especially promising, primarily small hydropower stations on rivers in the mountains. 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) [14] 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 2000 to 2022 in Kyrgyzstan is demonstrated.

Table 5

Fossil fuel energy production from 2000 to 2022 in Kyrgyzstan

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2000	2	432	13,75
2001	2	474	16,09
2002	2	430	16,82
2003	2	382	12,66
2004	2	405	12,98
2005	2	381	13,52
2006	2	368	13,52
2007	2	372	13,51
2008	1,5	294	13,55
2009	0,7	150	7,42

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

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 [15], 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 2000 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 2000 to 2022 has been illustrated.

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.

Table 6.

Low carbon energy and renewable energy production in Kyrgyzstan from 2000 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)
2000	-	13,55	-	-	2,746	86,25
2001	-	12,31	-	-	2,471	83,91
2002	-	10,68	-	-	2,125	83,18
2003	-	13,38	-	-	2,637	87,34
2004	-	13,95	-	-	2,716	87,02
2005	-	12,66	-	-	2,438	86,48
2006	-	12,35	-	-	2,354	86,48
2007	-	12,61	-	-	2,382	86,49
2008	-	10,02	-	-	1,875	86,45
2009	-	10,11	-	-	1,867	92,58
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

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 2000 to 2022 in Turkmenistan has been illuminated.

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 2000 till 2021 respectively.

Table 7.

Fossil fuel energy production from 2000 to 2022 in Turkmenistan

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2000	9	2024	100
2001	10	2151	100
2002	10	2141	100
2003	10	2133	100
2004	11	2324	100
2005	12	2466	100
2006	13	2590	100
2007	14	2782	100
2008	14	2771	100
2009	15	2899	100
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

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 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. In the following table 8 [16], we have illustrated the electricity consumption in Uzbekistan by sectors in 2019.

Table 8.

Uzbekistan electricity consumption by sector, 2019

Sectors	Electricity consumption
Industry	**40%**
Population	**23%**
Agriculture	**20%**
Utility	**13%**
Transport	**3%**
Construction	**1%**

From the table it is obvious that most of the electricity is consumed by the industries, both lite industry and heavy industries. Next is population, there is some part of the countries who does not have any electricity supply, but in Uzbekistan most parts of the country is supply by the 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 [17]. The strategy has many objectives within several priority areas for electricity production from fossil fuels contains followings:

- reduce natural gas losses in the production, processing, transportation and distribution stages by upgrading compressor stations, low- and medium-pressure gas distribution networks, and the gas transportation system with effective technologies for monitoring hydrocarbon resource losses (i.e. a supervisory control and data acquisition [SCADA] system);
- introduce modern gas distribution and metering technologies;
- reduce greenhouse gas (GHG) emissions during the processing and storage of oil and petroleum products;
- reduce GHG emissions from the combustion of associated petroleum gases once processes for

their utilization and advanced processing have been introduced;

- introduce alternative energy sources at oil and gas production facilities;
- deploy waste gas heat recovery for power generation.

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 2000 to 2022.

Table 9

Fossil fuel energy production from 2000 to 2022 in Uzbekistan

Years	Annual production (in TWh)	Per capita production (in kWh)	Share of total electricity production (in %)
2000	39	1,545	87
2001	39	1,547	87
2002	41	1,585	87
2003	39	1,516	84
2004	38	1,467	81
2005	38	1,435	81
2006	39	1,458	89
2007	40	1,465	90
2008	36	1,290	89
2009	38	1,355	86
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
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.

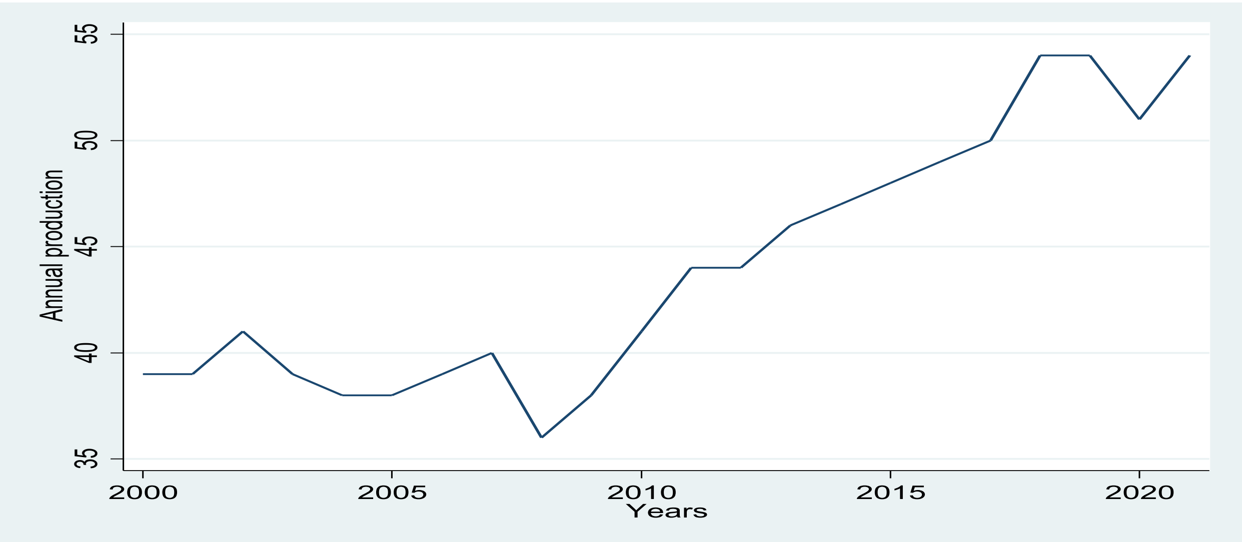


Figure 1. Tendency of changes on annual production of fossil fuel in

According to the graphical analysis, there is a trend and uncertainty in the time series of Annual production of fossil fuel during the years 2000–2021. Therefore, this time series is non-stationary. Taking into account the above, it is appropriate to use the ARIMA model to forecast Annual production of fossil fuel.

$$Y_t = c + \sum_{i=1}^{p} \alpha Y_{t-i} + \sum_{j=1}^{q} \theta e_{t-j} + e_t \qquad (1)$$

here: *c* – constant, *p* – order of autoregression, *q*– order of average moving, *e* – residual.

Dickey-Fuller test for unit root   Number of obs = 20

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-4.512	-3.750	-3.000	-2.630

MacKinnon approximate p-value for Z(t) = 0.0002

Figure 2. Dickey-Fuller test

According to the Dickey-Fuller test, $z(t) < 0{,}05$ it was determined that and the parameters of the ARIMA model were determined.

ARIMA regression

Sample: 2001 - 2021   Number of obs = 21
                                       Wald chi2(1) = 0.23
Log likelihood = -43.72424   Prob > chi2 = 0.6327

D. Annualproduction	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
Annualproduction						
_cons	.7056858	.4027699	1.75	0.080	-.0837288	1.4951
ARMA						
ma L1.	-.158045	.3306455	-0.48	0.633	-.8060984	.4900083
/sigma	1.939738	.319963	6.06	0.000	1.312622	2.566854

Note: The test of the variance against zero is one sided, and the two-sided confidence interval is truncated at zero.

Figure 3. Arima regression

$$\Delta Y_t = 0{,}7056858 - 0{,}158045\, Y_{t-i} + 1{,}939738\, e_{t-i}$$

The reliability of the constructed model was evaluated by Akaike and Bayesian criteria and the expected result was obtained.

Akaike's information criterion and Bayesian information criterion

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	21	.	-43.72424	3	93.44847	96.58204

Note: N=Obs used in calculating BIC; see [R] BIC note.

Figure 4. Akaike and Bayesian criteria

Medium-term forecast values of annual production of fossil fuel were developed based on the ARIMA model. In this following table 10, Mid-term forecast values of annual production of fossil fuel rare illustrated.

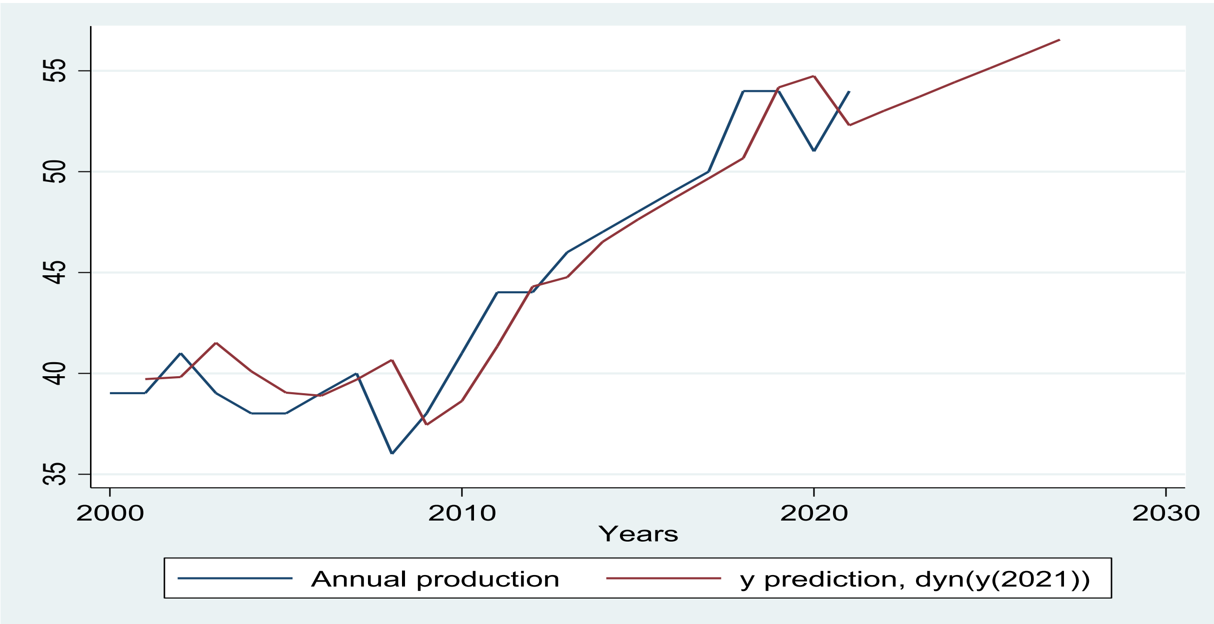
Table 10.

Mid-term forecast values of annual production of fossil fuel

Years	Future forecasts of annual production of fossil fuel (in TWh)
2023	53.707127
2024	54.412811
2025	55.118496
2026	55.824184
2027	56.529869

Source. Authors' work

Annual production of fossil fuel time series and forecast values for 2023-2027 were graphically analyzed in the figure 5.



Source. Authors' work

Figure 5. Change trends and future forecasts of annual production of fossil fuel

According to the results of the analysis, by 2027, the annual production of fossil fuel can reach 56.529869 TWh. That is, this indicator may increase by 1.07 times compared to 2022.

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 [18]. 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 2000 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 2000 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)
2000	-	5,82	0	-	233	13
2001	-	5,90	0	-	234	13
2002	-	6,12	0	-	239	13
2003	-	7,54	0	-	291	16
2004	-	8,92	0	-	340	19
2005	-	8,84	0	-	333	19
2006	-	4,65	0	-	173	11
2007	-	4,61	0	-	169	10
2008	-	4,44	0	-	160	11
2009	-	6,42	0	-	228	14
2010	-	8,11	0	-	283	17
2011	-	5,65	0	-	194	11
2012	-	6,59	0	-	223	13
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.

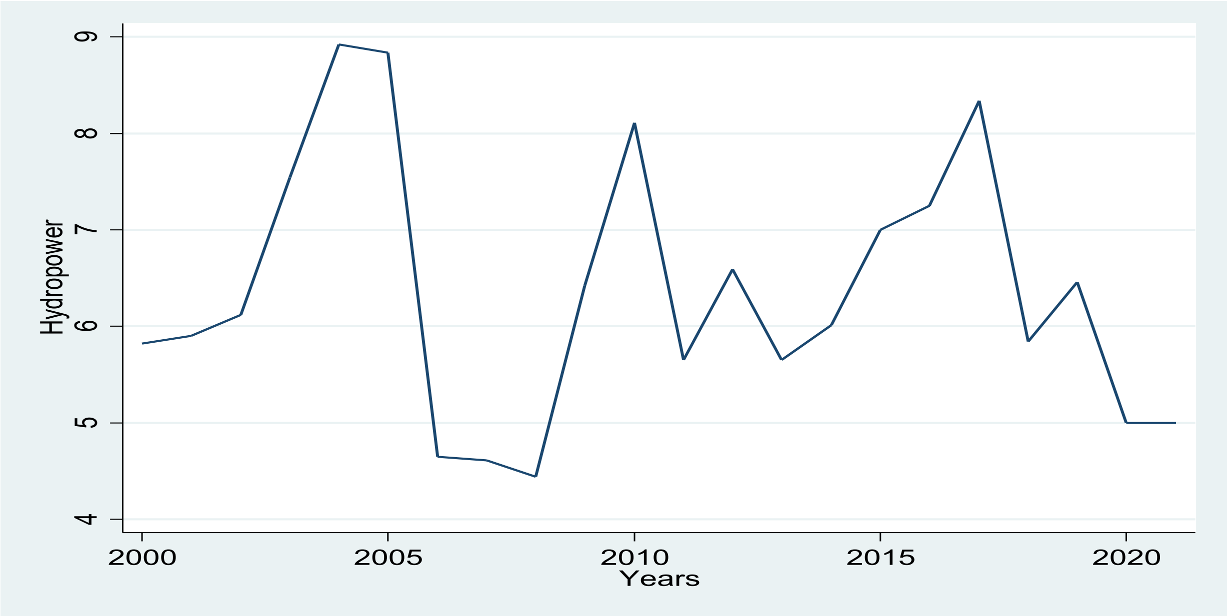


Figure 6. Changing trends of hydropower

According to graphical analysis, the time series of Hydropower from 2000 to 2021 has cycle and uncertainty. Therefore, this time series is non-stationary. Considering the above, it would be appropriate to use ARIMA model to forecast Hydropower [Figure 7].

Dickey-Fuller test for unit root Number of obs = 21

	Test Statistic	1% Critical Value	5% Critical Value	10% Critical Value
		Interpolated Dickey-Fuller		
Z(t)	-2.909	-3.750	-3.000	-2.630

MacKinnon approximate p-value for Z(t) = 0.0443

Figure 7. ARIMA model to forecast Hydropower

According to the Dickey-Fuller test, $z(t) < 0,05$ it was determined that and the parameters of the ARIMA model were determined.

```
ARIMA regression

Sample:  2001 - 2021                            Number of obs     =        21
                                                Wald chi2(1)      =      0.11
Log likelihood = -38.13255                      Prob > chi2       =    0.7347
```

D.Hydropower	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
Hydropower _cons	-.0399165	.4499107	-0.09	0.929	-.9217254	.8418923
ARMA ar L1.	-.1279843	.3775958	-0.34	0.735	-.8680585	.6120899
/sigma	1.486613	.2553951	5.82	0.000	.9860481	1.987178

Note: The test of the variance against zero is one sided, and the two-sided confidence interval is truncated at zero.

Figure 8. Arima regression

$$Y_t = -0,099165 - 0,1279843\,Y_{t-i} + 1,486613\,e_{t-i}$$

The reliability of the constructed model was evaluated by Akaike and Bayesian criteria and the desired result was obtained [Figure 9].

Akaike's information criterion and Bayesian information criterion

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	21	.	-38.13255	3	82.2651	85.39867

Note: N=Obs used in calculating BIC; see [R] BIC note.

Figure 9. Akaike and Bayesian criteria of reliability

Medium-term forecast values of Hydropower were developed based on the ARIMA model [Table 12].

Table 12.

Medium-term forecast values of Hydropower

Years	Hydropower (in TWh)
2023	5.041715
2024	5.001417
2025	4.96155
2026	4.921627
2027	4.881711

Hydropower's time series and forecast values for 2023-2027 were graphically analyzed. It should not be forgotten that the results of this forecast did not take into account the reforms of renewable energy and low-carbon energy production in our country, so we can observe a decrease in the forecast values. It should not be forgotten that the results of this forecast did not take into account the reforms of renewable energy and low-carbon energy production in our country, so we can observe a decrease in the forecast values [Figure 10].

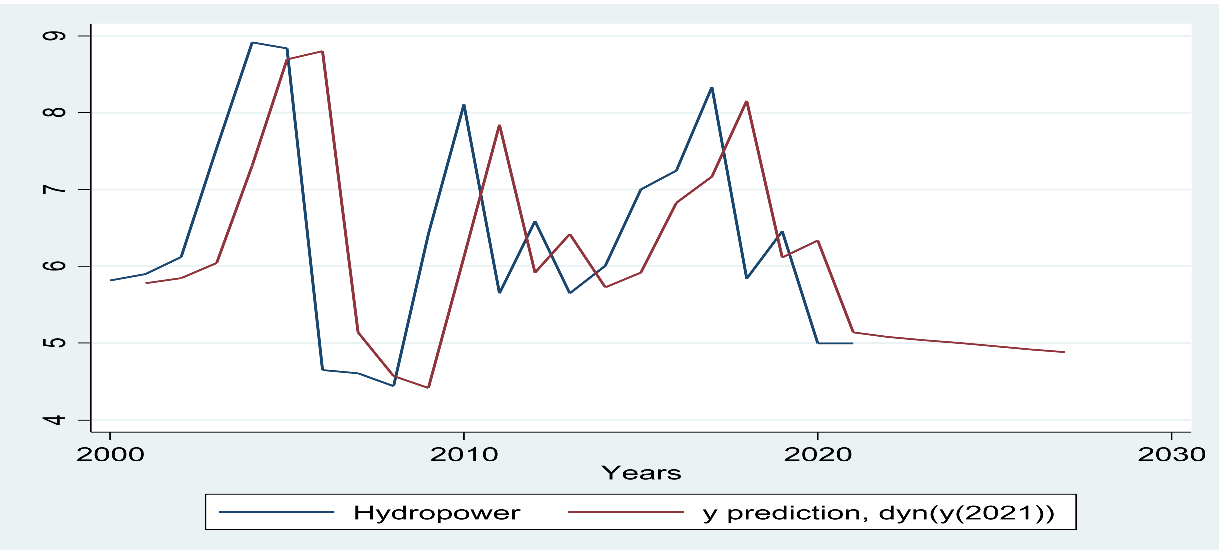


Figure 10. Hydropower's changing trends and future forecasts

According to the results of the analysis, by 2027, Hydropower can be 4.881711 TWh. That is, this indicator can be observed to decrease by 1.04 times compared to 2022 [Figure 11].

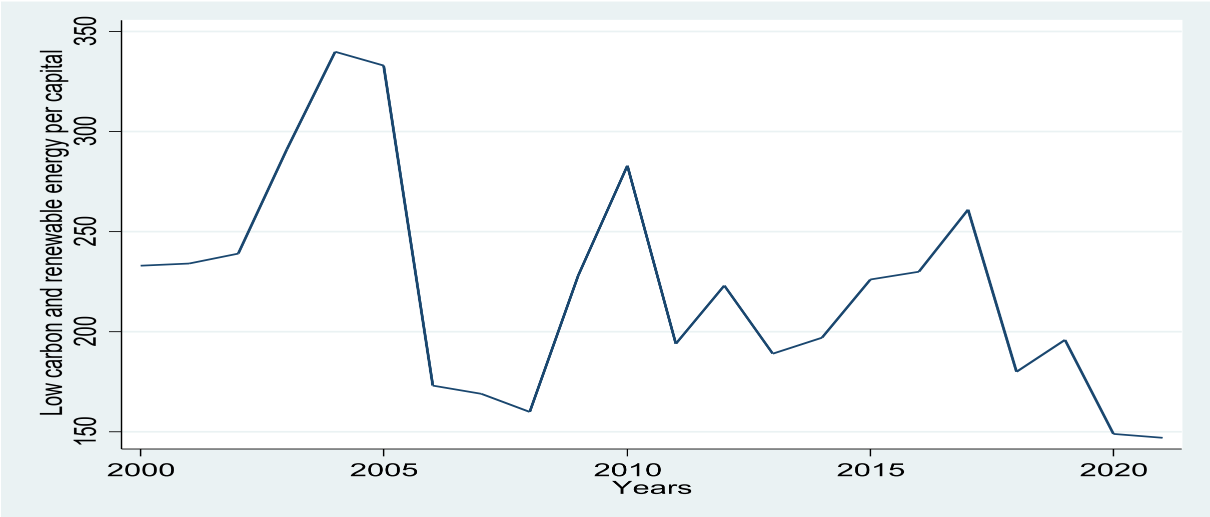


Figure 11. Changing tendency low carbon and renewable energy per capital

Dickey-Fuller test for unit root   Number of obs = 20

	Test Statistic	Interpolated Dickey-Fuller 1% Critical Value	5% Critical Value	10% Critical Value
Z(t)	-4.675	-3.750	-3.000	-2.630

MacKinnon approximate p-value for Z(t) = 0.0001

Figure 12. Dickey-Fuller test

According to the Dickey-Fuller test, $z(t) < 0{,}05$ it was determined that and the parameters of the ARIMA model were determined [Figure 13].

ARIMA regression

Sample: 2001 - 2021   Number of obs = 21
Wald chi2(1) = 0.05
Log likelihood = -113.0825   Prob > chi2 = 0.8173

D. Lowcarbonandrenewableenergy	Coef.	OPG Std. Err.	z	P>|z|	[95% Conf.	Interval]
Lowcarbonandrenewableenergy						
_cons	-4.125895	16.87693	-0.24	0.807	-37.20407	28.95228
ARMA						
ar L1.	-.0922288	.3991819	-0.23	0.817	-.8746109	.6901534
/sigma	52.75936	8.650482	6.10	0.000	35.80473	69.71399

Note: The test of the variance against zero is one sided, and the two-sided confidence interval is truncated at zero.

Figure 13. Arima regression model

$$\Delta Y_t = -4{,}125895 - 0{,}0922288 Y_{t-i} + 52{,}75936 e_{t-i}$$

The reliability of the constructed model was evaluated by Akaike and Bayesian criteria and the expected result was achieved [14].

```
Akaike's information criterion and Bayesian information criterion
```

Model	Obs	ll(null)	ll(model)	df	AIC	BIC
.	21	.	-113.0825	3	232.165	235.2986

Note: N=Obs used in calculating BIC; see **[R] BIC note**.

Figure 14. Akaike and Bayesian criteria for reliablity

Medium-term forecast values of low carbon and renewable energy per capital were developed based on the ARIMA model (Table 13).

Table 13

Mid-term forecast values of low carbon and renewable energy per capital

Years	Future forecasts of low carbon and renewable energy per capita (in kWh)
2023	140.2455
2024	136.1165
2025	131.9909
2026	127.865
2027	123.73906

Time series of low carbon and renewable energy per capital and forecast values for 2023-2027 were graphically analyzed. The main goal of today’s reforms is to reduce the negative impact on the environment, to satisfy unlimited needs from limited resources. Reforms aimed at increasing the share of renewable and low-carbon energy per capita are a clear proof of this.

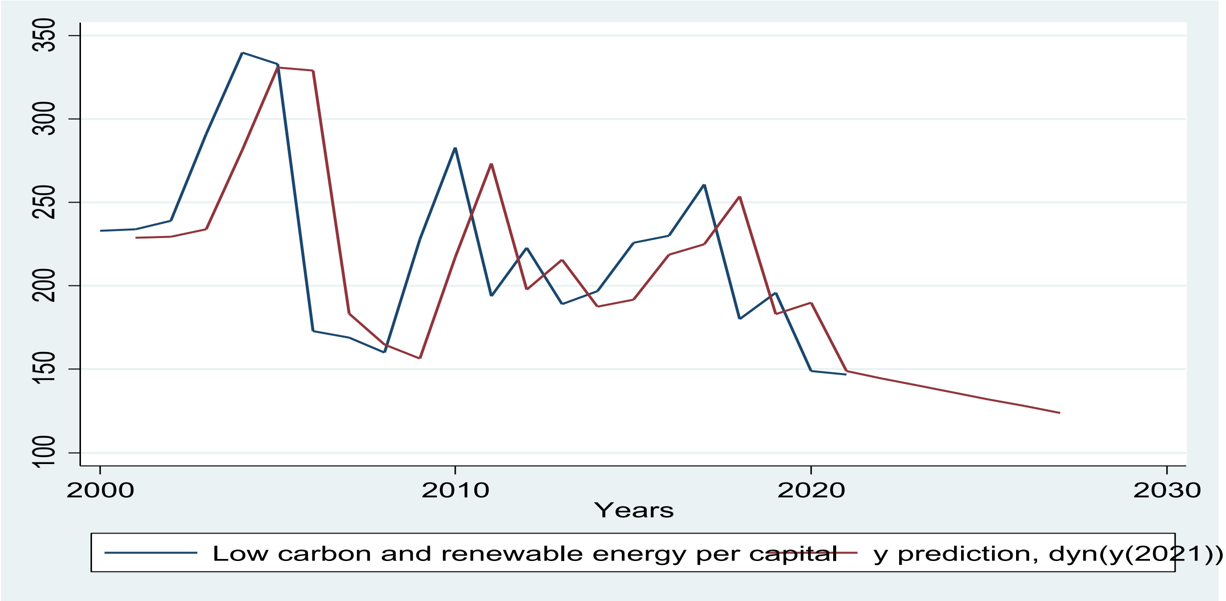


Figure 15. Low carbon and renewable energy per capital change trends and future forecasts

According to the forecast, by 2027, Low carbon and renewable energy per capital may reach 123.73906 kWh. That is, Low carbon and renewable energy per capital can be expected to decrease by 1.13 times compared to 2022.

Conclusion and recommendations:

Central Asian region, on the one hand, is rich in energy resources, but on the other hand, those energy resources are not evenly distributed or they are diverse. Unresolved water and energy issues are not only an obstacle to successful integration, but also occasionally lead to local conflicts and conflicts. For example, at the end of January of this year, electricity went out in a number of regions of Kazakhstan, Uzbekistan, and Kyrgyzstan, which caused supply interruptions in the entire energy chain. The problem was quickly resolved, but it showed that everything in our region is interconnected. As soon as the disaster happened, there were increasing calls for Uzbekistan and Kyrgyzstan to strengthen their energy systems and reduce dependence on neighboring countries. In other words, it covers Kazakhstan, Uzbekistan and Kyrgyzstan. The need for a shortened version of the single energy ring also raises questions.

Today, there are several major reasons for the revival of the energy industry in the Central Asian countries, these are as followings;

- In terms of export and import potential, the logistics system in the Central Asian countries has not been properly implemented;
- The potential of the Central Asian countries in terms of electric energy is not being paid enough attention;
- The lack of investment flows to the territory of Central Asian countries specifically for renewable and low-carbon energy;
- Rapid growth of the population in terms of demographics from year to year;
- We can mention that the level of one of the largest seas in Central Asia, the Aral Sea, is decreasing year by year, which in turn causes climate change.

With growing economies and populations, countries in Central Asia need ever more energy to fuel their development. At the same time, the increasing impacts of climate change in the region mean that countries must significantly cut their carbon emissions and accelerate the shift to clean and renewable power sources. Here are five things to know about the energy outlook for Central Asia [19].

1. Energy demand in the CAREC region (excluding the PRC) will grow by more than 30% by 2030.
2. Modernizing transmission and distribution infrastructure will improve energy efficiency.
3. Wind and solar are becoming highly competitive.
4. The CAREC region (excluding the PRC) needs around $340 billion in energy investments.
5. CAREC countries are taking action to cut their energy-related carbon emissions.

These are the key factors for central Asian countries to improve their energy outlook till 2030.

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% [20].

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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