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ON SMALL HYDROPOWER

World Small Hydropower Development Report 2022

Central Asia

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Central Asia

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Countries: Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, Uzbekistan

INTRODUCTION TO THE REGION

The electricity sectors of the countries in Central Asia share many common features due to their common history as constituent republics of the Soviet Union. Among these features is a high degree of regional interconnectivity of the national power grids through the infrastructure of the Central Asian Power System (CAPS), originally built during the Soviet period. However, in recent decades, participation in power sharing through CAPS has been suspended by Turkmenistan and partially by Uzbekistan. Another common feature is the advanced age of much of the power grid and generating capacities across the region due to a lack of adequate investment in the post-Soviet period, coupled with rising electricity demand outpacing grid capacities. While electricity access remains at or near 100 per cent across the region, interconnectivity and aging infrastructure have led to occasional cross-border power shortages and blackouts.

The role of hydropower in Central Asia differs from country to country. Kyrgyzstan and Tajikistan both have significant hydropower resources and their electricity sectors are dominated by generation from hydropower, providing Kyrgyzstan with over three quarters of the country's installed capacity and over 90 per cent of electricity generation, and Tajikistan with slightly under 90 per cent of installed capacity and over 90 per cent of generation. However, transboundary water disputes between these two countries have led to intermittent conflict followed by periods of negotiation over water use rights. In Kazakhstan and Uzbekistan, most electricity generation is from thermal power due to abundant reserves of fossil fuels, with hydropower playing a significant but supplementary role. Some hydropower capacity also exists in Turkmenistan, but its share of the country's energy mix is negligible and the country's electricity sector depends almost entirely on thermal power.

An overview of the electricity sectors of the countries in the Central Asia region is provided in Table 1.

Table 1. **Overview of Central Asia**

Country	*Total population (million people)*	*Electricity access, total (%)*	*Electricity access, rural (%)*	*Total installed capacity (MW)*	*Electricity generation (GWh/year)*	*Hydropower installed capacity (MW)*	*Hydropower generation (GWh/year)*
Kazakhstan	19	100	100	22,936	108,086	2,666	9,546
Kyrgyzstan	7	100	100	3,946	15,293	3,084	13,919
Tajikistan	10	100	100	6,124	20,676	5,406	19,169
Turkmenistan	6	N/A	N/A	6,511	24,000	1	N/A
Uzbekistan	35	100	100	15,949	66,407	1,908	5,019
Total	-	-	-	**55,466**	-	**13,065**	-

Source: *WSHPDR 2022*[1]

Note: Data in the table based on data contained in individual country chapters of the *WSHPDR 2022*; years may vary.

REGIONAL SMALL HYDROPOWER OVERVIEW

The definition of small hydropower (SHP) in Central Asia is largely inherited from the Soviet period and encompasses hydropower plants with a capacity of up to 30 MW in the case of Kyrgyzstan, Tajikistan and Uzbekistan. Kazakhstan follows the up to 35 MW definition, however, the up to 30 MW definition is also used occasionally, alongside the up to 10 MW definition used in renewable energy auctions. There is no definition of SHP in Turkmenistan.

A comparison of installed and potential capacities in the region is provided in Table 2.

Table 2. **Small Hydropower Capacities by Country in Central Asia (MW)**

Country	*Local SHP definition*	*Installed capacity (local def.)*	*Potential capacity (local def.)*	*Installed capacity (<10 MW)*	*Potential capacity (<10 MW)*
Kazakhstan	Up to 35 MW	255.0	2,354.4	118.0	1,380.9
Kyrgyzstan	Up to 30 MW	53.8	N/A	53.8	311.8
Tajikistan	Up to 30 MW	142.1	N/A	54.7	30,000.0
Turkmenistan	N/A	N/A	N/A	1.2	1,300.0
Uzbekistan	Up to 30 MW	303.6	1,392.0	87.8	87.8*
Total	-	-	-	**315.5**	**33,080.5**

Source: *WSHPDR 2022*

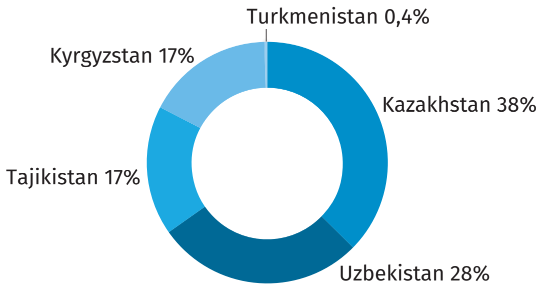
Note: *Based on installed capacity.

The total installed capacity of SHP up to 10 MW in Central Asia is 315.5 MW, while the potential capacity is estimated at 33,080.5 MW, with Tajikistan accounting for over 90 per cent of the total estimated potential. Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity of SHP up to 10 MW has increased by nearly 19 per cent, while the estimate of potential capacity has decreased by nearly 4 per cent, mainly due to a re-evaluation of data on the potential SHP capacity of Kazakhstan.

The SHP sector is well-developed in all countries in Central Asia with the exception of Turkmenistan. The largest installed SHP capacities, according to the local definition, are in Uzbekistan and Kazakhstan, where they form a significant share of total installed hydropower capacity. Conversely, the largest assessed SHP potential in the region is found in Tajikistan, a country defined by mountainous topography and abundant hydropower resources. SHP has a long history in Central Asia, with the first SHP plants constructed just prior to the First World War. In recent years, SHP in the region has seen active development, with private companies playing an increasingly prominent role.

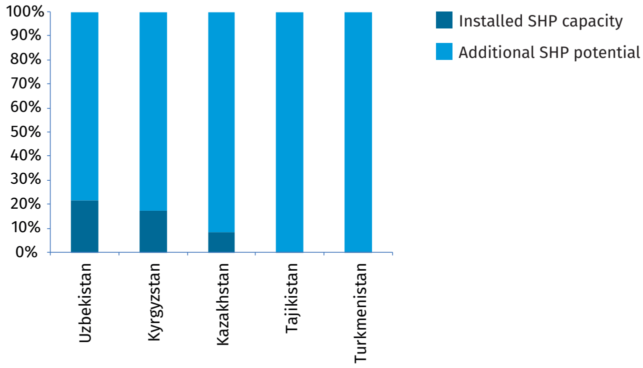
The national share of regional installed capacity for SHP up to 10 MW by country is displayed in Figure 1, while the share of total national SHP potential utilized by countries in the Central Asia region is displayed in Figure 2.

Figure 1. **Share of Regional Installed Capacity of Small Hydropower up to 10 MW by Country in Central Asia (%)**



Source: *WSHPDR 2022*[1]

Figure 2. **Utilized Small Hydropower Potential by Country in Central Asia (%)**



Source: *WSHPDR 2022*[1]

Note: For SHP up to 10 MW except in the case of Uzbekistan, where the local definition of SHP is used due to lack of other data.

The installed SHP capacity of **Uzbekistan** is estimated at 303.6 MW for SHP up to 30 MW and at 87.8 MW for SHP up to 10 MW. Potential capacity for SHP up to 30 MW is estimated at 1,392 MW, indicating that approximately 22 per cent has been developed. No estimate of potential capacity for SHP up to 10 MW is available. During the mid-20th century, there were over 250 operational SHP plants in the country, but most of these are no longer in use. In recent years, the Government has actively pursued SHP development, launching an ambitious programme of SHP construction and refurbishment in 2017. The programme includes specific plans to add an additional 35 new SHP plants with a total installed capacity of 349 MW and to increase the installed capacity of 23 existing plants to 251.4 MW by 2030. Several new SHP plants were commissioned and one plant was refurbished in 2019.

The installed SHP capacity of **Kazakhstan** for SHP plants up to 35 MW was 255 MW as of mid-2021, while potential capacity is estimated at 2,354.4 MW, indicating that approximately 11 per cent has been developed so far. For SHP up to 10 MW, installed and potential capacity is 118 MW and 1,380.9 MW, respectively, indicating that approximately 9 per cent has been developed. As in Uzbekistan, a large number of SHP plants were constructed in Kazakhstan during the Soviet period and many have since fallen into disuse or require extensive rehabilitation. The country aims to add up to 1,500 MW of SHP capacity by 2030.

In **Kyrgyzstan**, there were a total of 18 SHP up to 10 MW plants operating as of 2020, with an installed capacity of 53.8 MW. Although the national definition of SHP includes plants up to 30 MW, in practice, there are no hydropower plants with a capacity of between 10 MW and 30 MW in the country. Potential capacity for SHP up to 10 MW is estimated at 311.8 MW, indicating that 17 per cent of the known potential has been developed. The construction of new SHP plants in Kyrgyzstan in recent years has been carried out solely by private sector developers. A number of government initiatives targeted the addition of 41 new SHP plants with a total capacity of 178 MW by 2025, but the pace of development has lagged due to issues with funding, project delays, as well as institutional, legal and technical obstacles.

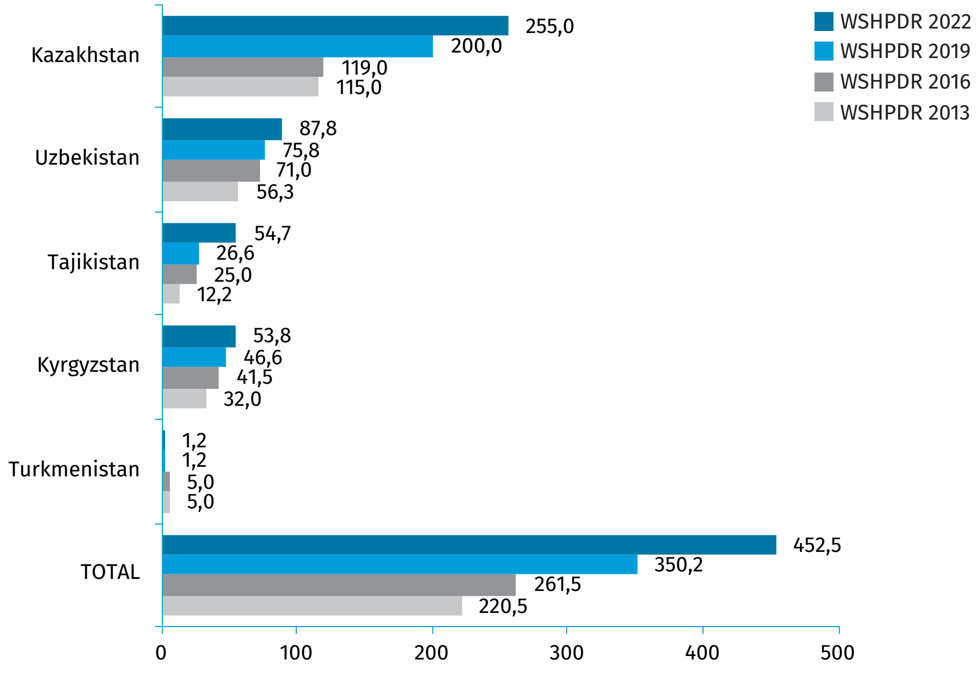
Although the definition of SHP in **Tajikistan** includes plants up to 30 MW, in practice, the SHP fleet of the country is largely composed of hundreds of very small plants with capacities ranging from several hundred kilowatts to several megawatts.

The total installed capacity of SHP up to 30 MW in Tajikistan as of 2021 was 142.1 MW, of which 44.8 MW was operated by the private-public company Pamir Energy to supply electricity to the semi-isolated Gorno-Badakhshan Autonomous Region, powered solely by SHP. The installed capacity of SHP up to 10 MW in 2021 was 54.7 MW, while the potential SHP capacity up to 10 MW is estimated at 30,000 MW, suggesting that only a small fraction of this potential has been developed so far. Extensive plans for the construction of SHP in Tajikistan were drawn up during the Soviet period but only partially realized. The construction of SHP plants picked up again after 1995, with 155 plants constructed between 1995 and 2021 with a cumulative capacity of 12.5 MW.

The only operational SHP plant of **Turkmenistan**, the Hindigush hydropower plant on the Murgab River, was built in 1913 with a capacity of 1.2 MW and remains in use to this day. The country's SHP potential is estimated at 1,300 MW, indicating that less than 1 per cent has been developed. Plans for the refurbishment of several previously operational SHP plants as well as the construction of new plants have been proposed since 2011 but have not been realized.

Changes in the installed SHP capacities of countries in the Central Asia region compared to the previous editions of the *World Small Hydropower Development Report (WSHPDR)* are displayed in Figure 3.

Figure 3. **Change in Installed Capacity of Small Hydropower from *WSHPDR 2013* to *WSHPDR 2022* by Country in (MW)**



Source: *WSHPDR 2022*,[1] *WSHPDR 2013*,[2] *WSHPDR 2016*,[3] *WSHPDR 2019*[4]

Note: For SHP up to 10 MW except in the case of Kazakhstan, where the local definition of SHP is used for purpose of comparison with previous years.

Climate Change and Small Hydropower

The glacierized areas in this region show increased summer and winter runoff. Meanwhile, the areas with a lower fraction of glaciers present an increased interannual variation in streamflow. The magnitude of the projected runoff varies significantly across climate change scenarios. For example, Kazakhstan estimates that precipitation could increase up to 10 per cent by 2050. Kyrgyzstan forecasts that climate change will lead to a decrease in hydropower potential, even though SHP can be a great strategy to mitigate energy shortages in remote areas in the short term.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The main barriers to SHP development in **Kazakhstan** include an aging power grid unable to accommodate significant additional SHP development, problems with financing and the cheap cost of generation from fossil fuels, in addition to a lack of up-to-date studies on SHP potential in the country. At the same time, the regulatory framework is strongly supportive of SHP development and the Government has outlined specific plans with clear targets for the construction of significant additional SHP capacities by 2030. Incentives for SHP in Kazakhstan include tax, customs and connection fee waivers, guaranteed purchase prices and periods, as well as in-kind aid.

Uzbekistan shares several barriers to SHP development with Kazakhstan, including an aging power infrastructure, low cost of electricity from fossil fuels and lack of up-to-date studies of SHP potential. In addition, there is a lack of clear government incentives and private financing for SHP projects, although several new policies articulating government support for SHP development have been adopted in recent years. The main enablers for SHP development in the country include the large number of decommissioned or abandoned SHP plants that may be refurbished, as well as the significant untapped SHP potential on both natural watercourses and manmade canals.

The development of SHP in **Kyrgyzstan** is hindered by many obstacles, including a lack of government financing, institutional and legal barriers as well as political and economic instability. In addition, there are material factors impeding SHP construction in Kyrgyzstan such as a lack of technical capacities and environmental hazards including flooding, bank erosion, potential seismic risk and severe winter weather. Enabling factors include a large untapped SHP potential assessed across several studies, existing framework of preferential tariffs for SHP projects and the high cost of electricity generation from fossil fuels in the country, which has increased demand for alternative energy sources.

In **Tajikistan**, barriers to SHP development include the fragmentary nature of SHP planning and construction, which has resulted in a proliferation of mini- and micro-hydropower plants with higher per-kilowatt costs than those of larger plants, as well as the low electricity tariff caps mandated by the Government, which make it difficult to recoup the cost of new SHP construction. Despite this, financing for SHP in Tajikistan is generally more readily available than for larger hydropower projects, and the country's massive SHP potential suggests opportunities for new projects are available.

While abundant SHP potential exists in **Turkmenistan**, the main barrier to its development has been the country's access to cheap domestically-sourced fossil fuels. However, renewable energy has been receiving increasing attention in the country in recent years, leading to the adoption of several national renewable energy policies as well as bilateral agreements on cooperation in the renewable energy sector. The ongoing construction of the Altyn-Asyr water conveyance network presents an additional opportunity for the realization of SHP projects with a reduced environmental impact.

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Kazakhstan

Galina Livingstone, Livingstone Environmental Ltd.

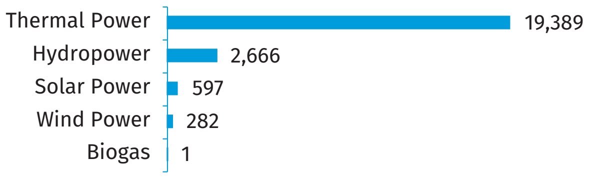
KEY FACTS

Population	18,631,779 (2020)[1]
Area	2,724,900 km^2 [2]
Topography	Most of the country lies between 200 and 300 metres above sea level. Just over 70 per cent of the country is desert, semi-desert or steppe. A vast flat steppe extends from the Volga River in the west to the Altai Mountains in the east and from the plains of Western Siberia in the north to the oases and deserts of Central Asia in the south. Kazakhstan is mountainous along its far eastern and south-eastern borders, where much of the forested Altai and Tian Shan ranges remain snow-capped throughout the year and with many elevated peaks exceeding 6,500 metres. The highest point is Mount Khan Tengri at 7,010 metres above sea level.[3]
Climate	The climate is extreme continental (excluding the south) with cold winters and hot summers. The average temperature in January ranges from -19°C in the north to -4°C in the south and in July from 19 °C in the north to 26 °C in the south. The lowest and the highest temperature records are extreme (-57 °C and +49 °C). Approximately 90 per cent of the country lies in the arid and semiarid zones. There are frequent high winds and dust storms due to the clashes between different air masses, especially in spring.[4,5]
Climate Change	The average annual air temperature in Kazakhstan is gradually increasing at the rate of 0.31 °C every 10 years, as observed between 1936 and 2005. A 1.4 °C increase in mean annual temperature is expected by 2030. The country is facing significant impacts resulting from climate change, including increased aridity, challenges in water management, extreme weather events and the degradation of glaciers.[4,5]
Rain Pattern	The rainiest part of the country lies in the north (roughly above the 50th parallel), where the average annual precipitation exceeds 300 mm. Precipitation drops to approximately 150–200 mm in the centre and south and to as low as 100 mm around the Aral Sea. Average annual precipitation is higher in the south-eastern mountainous area, e.g., the average annual precipitation in Almaty amounts to 585 mm. Snow is frequent in winter, but it is often light.[6]
Hydrology	Four major hydrological regions can be distinguished in Kazakhstan: the Ob River basin draining to the Arctic Ocean, the Caspian Sea basin, the Aral Sea basin and internal lakes, depressions or deserts. Kazakhstan has 8,500 small and large rivers and approximately 48,000 lakes. The main water basins in the country are the Chu-Talas, Aral-Syr Darya, Balkhash-Alacol, Ural-Caspian, Nura-Sarysu, Tobol-Turgai, Irtysh and Ishim basins. The distribution of surface water resources within the country is extremely uneven and is marked by significant perennial and seasonal dynamics. Central Kazakhstan has only 3 per cent of the country's total water resources. The western and south-western regions (Atyrau, Kyzylorda and Mangystau regions) are highly water-deficient. The Balkhash-Alakol and Irtysh River basins in the east and north-east account for almost 75 per cent of surface water resources generated within the country. Approximately 90 per cent of the runoff occurs in spring, exceeding reservoir storage capacity.[6]

ELECTRICITY SECTOR OVERVIEW

As of 1 January 2020, there were 179 power plants operating in Kazakhstan with a total installed capacity of 22,936 MW, including 19,389 MW (85 per cent) provided by thermal power plants, 2,666 MW (12 per cent) by hydropower plants, 597 MW (3 per cent) by solar power, 282 MW (1 per cent) by wind power and 1 MW (less than 1 per cent) by a biogas plant (Figure 1). Available capacity at the beginning of 2020 was somewhat lower than installed capacity, at 19,329 MW, while the maximum daily capacity load over the course of 2019 was 15,182 MW.[7,8,9]

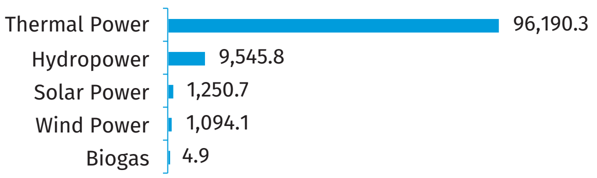
Figure 1. **Installed Electricity Capacity by Source in Kazakhstan in 2020 (MW)**



Source: Samruk Energy[7]

Total electricity generation in 2020 equalled 108,085.8 GWh, of which 96,190.3 GWh (89 per cent) was provided by thermal power, 9,545.8 GWh (9 per cent) by hydropower, 1,250.7 GWh by solar power (1 per cent), 1094.1 GWh (1 per cent) by wind power and 4.9 GWh (less than 1 per cent) by biogas (Figure 2).[7,10] Electricity imports in 2020 amounted to 1,555.4 GWh, while exports reached 1,968.7 GWh.[10]

Figure 2. **Annual Electricity Generation by Source in Kazakhstan in 2020 (GWh)**



Source: Samruk Energy[7,10]

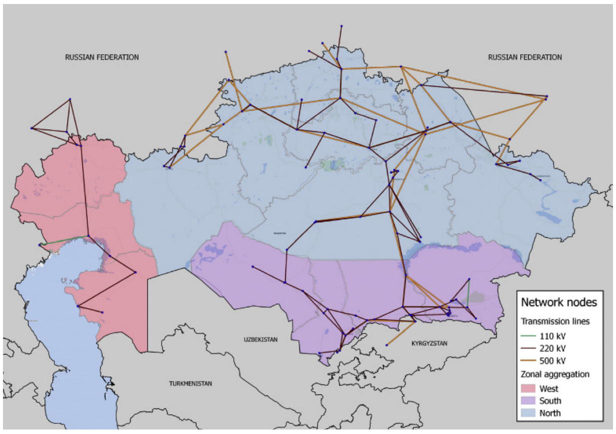
Access to electricity in Kazakhstan is 100 per cent.[11] Consumption of electricity in 2020 amounted to 107,344.8 GWh.[7,10] Both consumption and generation of electricity have been gradually increasing over the last decade. On average, the annual increase in electricity production between 2015 and 2020 was 2 per cent, while the increase in consumption was 3 per cent. Should this trend continue, the country would experience a generation deficit by 2027, provided no additional generation capacities are commissioned. Economic development of the country is expected to cause further growth in consumption, increasing at over 2 per cent per year until 2030 and reaching 136 TWh, and by over 1 per cent per year between 2030 and 2050 to reach 172 TWh.[12,13] The power sector of Kazakhstan is additionally hobbled by aging Soviet-era assets: 65 per cent of the equipment is over 20 years old and 31 per cent over 30 years old, with at least 60 per cent of equipment requiring modernization.[14] Consequently, the number of technical failures and interruptions has been on the rise, increasing from 4,010 in 2019 to 4,458 in 2020.[15]

While the Government of Kazakhstan is implementing plans for the modernization of the power sector, major state-financed programmes are lacking and the attraction of investments in the power sector is carried out within the framework of the electricity market. Kazakhstan has been particularly successful in attracting investments in the hydropower sector, totalling USD 2.78 billion in 2020 (nearly 2 per cent of the Gross Domestic Product).[16]

The structure of the electric power sector of Kazakhstan is composed of several economically independent entities, including electricity producers, primarily privately-owned; the national electricity grid operator Kazakhstan Electricity Grid Operating Company (KEGOC), operating the backbone grids of 220/500/1150 kV; and regional electricity companies (RECs), both private and state-owned, operating grids of 110 kV and below.[9] The National Welfare Fund of Kazakhstan, Samruk-Kazyna JSC, is the main shareholder of KEGOC with 90 per cent state ownership. It also holds a 100 per cent stake in Samruk-Energy JSC, which operates most of major power plants in the country. In terms of operational dispatch management in the United Energy System of the Republic of Kazakhstan (UES RK), nine regional dispatch centres are in direct operational subordination to the KEGOC's Unified Dispatching Office.[17,18,19]

Geographically, the country is serviced by three electric infrastructure zones — the North, South and West (Figure 3). The North and South zones are integrated as the UES RK, a set of power plants, power lines and substations operated by KEGOC provide energy supply to consumers in the two zones. In its turn, the West zone is isolated from the UES RK due to its geographical remoteness and sparse population, although there are plans to integrate the West zone with the UES RK in the future.[17,20]

Figure 3. **Electric Power Infrastructure Zones in Kazakhstan**



Source: Assembayeva et al.[21]

Each of the three electric power infrastructure zones of Kazakhstan is connected to power grids in the neighbouring ex-Soviet countries: the North and West zones are connected to the United Energy System (UES) of the Russian Federation, while the South zone is integrated with the Central Asian UES.[20,22] In addition, Kazakhstan, as a member of the Eurasian Economic Union (EAEU), is working on the establishment of a common electricity market in the EAEU by integrating the national electricity markets of Armenia, Belarus, Kazakhstan, Kyrgyzstan and Russia on the basis of parallel electric power systems.[23]

The North zone generates more than 77 per cent of all electricity in the country and accounts for approximately two thirds of national electricity consumption, while containing only 41 per cent of the country's population, due to the concentration of industrial consumers in the region. The South zone accounts for 21 per cent of consumption, but it is power-deficient and covers power shortages by supplies from the North zone and the Central Asian UES. The West zone is also characterized by power deficits and relies on electricity imports from Russia.[24]

Despite the overall surplus of electric capacity in the country, there is a shortage of flexible capacity capable of quickly compensating the power deficit in the UES RK during the peak loads due to a high degree of reliance on coal-fired power plants. Opportunities for the construction of new large-scale hydropower plants for the purpose of providing this capacity are limited in the country and current plans to develop flexible capacity focus mostly on the construction of additional gas-fired power plants by 2025.[25,26]

According to the Law on the Electric Power Industry of the Republic of Kazakhstan, electric power in the country is traded at the wholesale and retail markets.[27] From 1 January 2019, a new wholesale electric power market was launched in Kazakhstan, which divided the electricity market into two separate segments: the capacity supply segment and the electricity supply segment. Within the framework of the wholesale electricity market, the wholesale electricity tariff is divided into two parts:

- A set capacity tariff for maintaining readiness of the generating capacity;
- A variable electricity tariff that ensures return on the cost of electricity production.

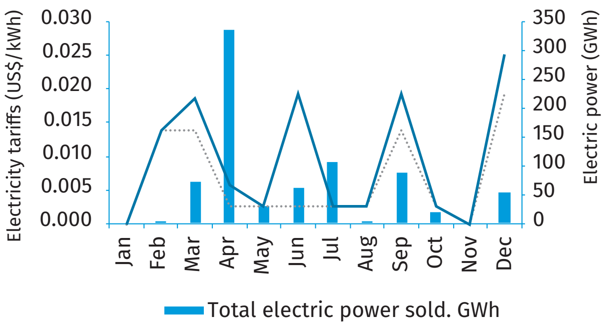
The maximum wholesale market tariffs for individual electric energy generating companies are set by the Ministry of Energy of the Republic of Kazakhstan and regulated by the Agency for Protection and Development of Competition. The tariffs are established in accordance with national legislation and capped with consideration of the socio-economic conditions in the country.

The capacity supply segment was added in 2019 to the already existing electricity supply market to encourage investments in the renovation of old power facilities and the construction of new ones. All generating companies in Kazakhstan must maintain a specific generating capacity and all consumers participating in the wholesale electric power market have an obligation to pay for the availability of the specific generating capacity.

In 2020–2021, the maximum monthly capacity tariff was fixed at 590,000 KZT/MW (1,437.7 USD/MW) (excluding value-added tax (VAT)). Although the Law on the Electric Power Industry stipulates that the approved wholesale tariffs should be fixed for seven years, the Ministry of Energy can allow raising them earlier at the request of electricity generating companies in case of a proven increase in their power generation expenditures (e.g., associated with modernization of their assets).[27,28,29] According to the Law, the Financial Settlement Centre of Renewable Energy LLP (FSC) of KEGOC concludes contracts with power producers for maintaining availability of the capacity supply. The fees for the capacity supply services are included in the general fees paid by the consumers; they are collected by FSC, and consequently paid to the power plants. Thus, the costs of building new power plants and the expansion and modernization of existing power plants are distributed evenly among all consumers.[30]

For the electricity supply segment of the wholesale market, power producers independently establish their electricity tariffs, within the maximum tariff cap approved by the Ministry of Energy.[27] Wholesale electricity tariffs vary throughout the year. The highest tariff per kWh in 2020 was in December at 10.39 KZT/kWh (0.03 USD/kWh) (Figure 4).[28]

Figure 4. **Dynamics of the Wholesale Electric Energy Market in Kazakhstan in 2020**



Source: Market Council of the Kazakhstan Electric Power Association[28]

In the retail electric power market, electricity supply companies purchase electricity, either directly from power producers or at centralized auctions carried out on the wholesale market, and then sell it to the retail consumers. The retail tariffs for electricity in Kazakhstan are very low in comparison with many other countries. For example, the maximum electricity tariff per 100 kWh for households in Kazakhstan in 2020 was fixed at approximately 0.03 USD, while the world average for the same year was 13.7 USD.[28,29,31] However, electricity tariffs are gradually rising, having increased by nearly 7 per cent in 2020 relative to the previous year.[28,29]

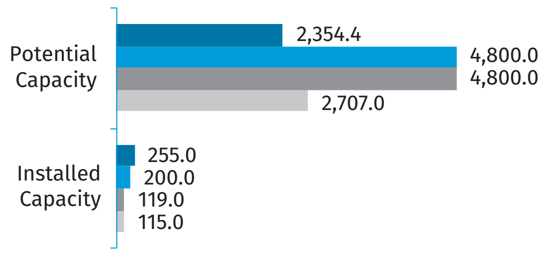
SMALL HYDROPOWER SECTOR OVERVIEW

Hydropower is a major source of electricity production in Kazakhstan. The country's hydropower resources are concentrated in the Eastern, Southern and South-Eastern regions.[32] The technical potential of hydropower in the country is approximately 62 GWh per year, while the economically feasible potential is estimated at 25–27 GWh per year.[33,34] These figures contrast with actual hydropower generation from available capacities, which totalled approximately 9.5 TWh in 2020 (Figure 2).

The definition of small hydropower (SHP) in Kazakhstan, established by the 2009 Law on Supporting the Use of Renewable Energy Sources (RES) for identifying hydropower plants eligible for incentives, applies to hydropower plants of up to 35 MW installed capacity and without reservoirs.[35] Otherwise, there is no formal regulatory definition of SHP in the country. The up to 30 MW definition, inherited from regulations in force during the Soviet period, is used occasionally, while state-supported auctions for RES use the up to 10 MW definition. Consequently, the upper threshold for SHP in Kazakhstan varies across publications. In the current chapter, both the 10 MW and 35 MW definitions are considered.

As of mid-2021, the total installed capacity of SHP in Kazakhstan was 255 MW for plants of up to 35 MW installed capacity and approximately 118 MW for SHP up to 10 MW.[36] Potential capacity for SHP up to 35 MW has been estimated at 4,800 MW by the United Nations Development Programme (UNDP).[23] However, previous detailed studies of regional hydropower potential suggest a more modest figure of 2,354.4 MW for SHP up to 30 MW and 1,380.9 MW for SHP up to 10 MW (Table 2).[37] The 2,354.4 MW estimate is taken as more accurate and representative of potential capacity for SHP up to 35 MW, as no detailed studies of potential capacity for SHP between 30 MW and 35 MW have taken place and in practice, very little such potential is believed to actually exit in the country.[12] Compared to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity of SHP up to 35 MW has increased by nearly 28 per cent due to the commissioning of several SHP plants in recent years, while the estimated potential capacity has decreased by approximately 51 per cent due to a reassessment of available data from previous studies (Figure 5).[38]

Figure 5. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Kazakhstan (MW)**



Source: Ministry of Energy,[36] UNDP,[37] *WSHPDR 2019*,[38] *WSHPDR 2013*,[39] *WSHPDR 2016*[40]

Note: Data for SHP up to 35 MW.

Many SHP plants were constructed and operated in Kazakhstan during the Soviet period, but most have since been abandoned and are too dilapidated to allow renovation. However, there are notable exceptions, such as SHP plants No.6, No.7 and No.8 near Almaty, constructed in the 1940s for powering heavy industry evacuated to Kazakhstan from other parts of the Soviet Union during World War II. These plants, originally equipped with Leffel turbines and 2.5 MW General Electric generators supplied to the Soviet Union by the United States during the war through the Lend-Lease Programme, are still in operation today, although in a state requiring major renovations.[41] More recently, individual SHP plants and cascades of plants have been constructed on the Issyk, Karatal, Kora, Lepsy and Keles Rivers, among others. Many of the older SHP plants require extensive renovation. A partial list of existing SHP plants in Kazakhstan in displayed in Table 1.

Table 1. **List of Selected Existing Small Hydropower Plants in Kazakhstan**

Name	*Location (River)*	*Capacity (MW)*	*Head (m)*	*Type of plant*	*Operator*	*Launch year*
Turgusun-1	Turgusun	24.9	N/A	Run-of-river	Turgusun-1, LLP	2021
Chazhinskaya-2	Chazha	25.8	N/A	Run-of-river	ASPMK-519, LLP	2021
Darkhan	Keles	4.2	15.0	Run-of-river	SmartReEnergy, LLC	2020
Issyk-1	Issyk	5.0	144.5	Run-of-river	HydroPower, LLP	2019
Ulbinskaya	Tikhaya	27.6	155.0	Run-of-river	Kompaniya LK GES, LLP	1937/ 2019
Korinskaya-2	Kora	2.1	83.7	Run-of-river	Korinskaya GES, LLP	2017
Mankent	Aksu	2.5	N/A	Run-of-river	Aksu-Energo, LLP	2017
Korinskaya-1	Kora	28.5	121.0	Run-of-river	Korinskaya GES, LLP	2017
Lepsy-2	Lepsy	17.0	40.0	Run-of-river	GES Lepsy, LLP	2016
Verkhne-Baskanskaya-1	Baskan	4.5	50.0	Run-of-river	Baskan Power, LLP	2015
Ryszhan	Keles	2.0	25.0	Run-of-river	SmartReEnergy, LLC	2014
Intumakskaya	Nura	0.6	N/A	Run-of-river	Kazvodkhoz	2013
Karakystakskaya	Karakystak	2.3	107.6	Run-of-river	Zhambylskiye GES, LLC	2013
Tasotkelskaya-1	Chu	9.2	N/A	Run-of-river	Kompaniya A&T Energo, LLP	2013
Sarkandskaya	Sarkand	1.9	50.8	Run-of-river	Firma Tamerlan, LLP	1998/ 2013
Karatalskaya-2	Karatal	4.4	19.8	Run-of-river	Kaskad Karatalskikh GES, LLP	2010
Issyk-2	Issyk	5.1	160.0	Run-of-river	EnergoAlem, LLP	2008
Koshakar-Ata	Keles	1.3	7.6	Run-of-river	SmartReEnergy, LLC	2001
Antonovskaya-3	Lepsy	1.6	N/A	Run-of-river	Kainar-AKB, LLP	1960
Almatyinskaya-2	Kumbelsu	14.3	499.0	Run-of-river	Almaty Power Stations, JSC	1959
Karatalskaya-1	Karatal	10.1	46.2	Run-of-river	KazTzink, LLP	1954

Source: Various[12,41–57]

The majority of existing SHP plants in Kazakhstan as well as SHP potential sites are located on small rivers (less than 200 kilometres in length) in mountainous areas, where elevation differences enable the construction of SHP plants on relatively low-flow watercourses. Both in terms of technical and economic considerations, SHP development potential in Kazakhstan is highest in the south and south-east of the country, where abundant water resources are coupled with an existing power deficit. The most promising rivers for SHP construction in the region are the Ili, Charyn, Chilik, Karatal, Koksu, Tentek, Khorgos, Tekes, Talgar, Major and Minor Almaty, Usek, Aksu, Lepsy, and Yrgaity Rivers.[58]

Data provided by the Almaty Hydroproject Institute and published in an Energy Sector Management Assistance Programme (ESMAP) report in 1997 surveyed SHP potential on rivers across the country. Regional totals of SHP potential, indicating the number of potential sites, potential capacity and estimated annual generation identified by the study, are summarized in Table 2. According to the report, Almaty Oblast alone accounts for nearly half of all SHP potential capacity and generation in the country.[23]

Table 2. **Small Hydropower Development Potential in Kazakhstan**

UES RK zone	Region	Installed capacity range (MW)	Number of SHP plants	Total potential capacity (MW)	Technical potential, annual average (GWh)
North	Eastern Kazakhstan Oblast	N≤10	58	176.1	704
		10<N≤30	18	377.0	1,669
		Total	76	553.1	2,373
South	Almaty Oblast	N≤10	191	661.7	3,129
		10<N≤30	30	472.7	2,161
		Total	221	1134.4	5,290
	Zhambyl Oblast	2<N≤10	92	208.1	1,020
		10<N≤30	2	23.6	108
		Total	94	231.7	1,128
	Turkestan Oblast	N≤10	112	335.0	1,462
		10<N≤30	4	100.2	452
		Total	116	435.2	1,914
All Kazakhstan		Total of N≤10	453	1,380.9	6,315
		Total of 10<N≤30	54	973.5	4,390
		Total of N≤30	507	2,354.4	10,705

Source: ESMAP[23]

The 2013 Plan for the Development of RES in 2013–2030 and the 2014 Concept of Development of the Fuel and Energy Complex of the Republic of Kazakhstan until 2030 targeted the construction of an additional 518.8 MW of SHP projects by 2030, including 119.1 MW in the North zone and 399.7 MW in the South zone.[33,59] However, most of these projects have not yet been implemented, mainly due to lack of funding. Another large-scale hydropower development plan approved by the Ministry of Energy in 2020 includes a new target to develop 1,500 MW of SHP by 2030.[60]

Ongoing SHP construction has been driven primarily by RES auctions. Several examples of SHP projects approved at recent RES auctions are provided in Table 3.

Table 3. **List of Selected Ongoing Small Hydropower Projects in Kazakhstan**

Name	Location	River	Capacity (MW)	Developer	Expected launch year	Project status
Koktal HPP 1.1	Kerbulakskiy District, Almaty Oblast	Koktal	8.6	National Energy Company Zharyk Energo, LLP	2022	Designed, construction started in 2019
Vekhne-Talaptinskaya	Koksuiskiy District, Almaty Oblast	Koksu	7.0	Bekzat, LLP	2022	Designed, construction started in 2020
N/A	Zharmiskiy district, Eastern Kazakhstan Oblast	N/A	1.0	UBS Power, LLP	2025	Design and approval stage
N/A	Tolebyiskiy District, Turkestan Oblast	Aksu	2.0	Jasyl Qýat, LLP	2025	Design and approval stage
N/A	Kazygutskiy District, Turkestan Oblast	Ulu-chur	1.5	Industrial Cooperative SPK Yntimak	2025	Design and approval stage

Source: KOREM[61]

Note: Status as of mid-2021.

RENEWABLE ENERGY POLICY

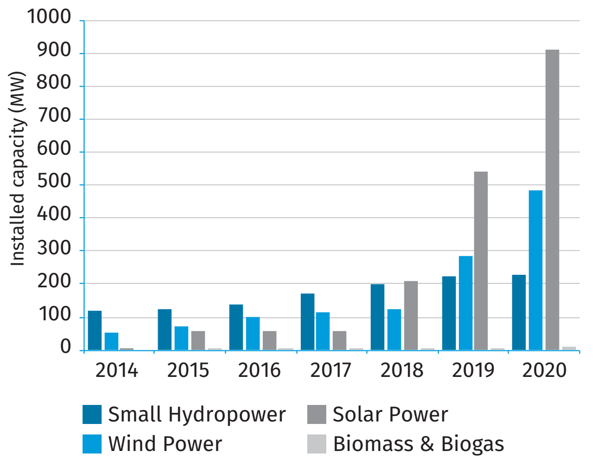
The regulatory framework of Kazakhstan governing RES development includes laws that apply to the power sector as a whole, such as the Law on the Electric Power Industry and the Law on Energy Saving and Energy Efficiency, as well as laws that specifically target the development of RES, including the 2009 Law on Supporting the Use of RES and the 2013 Presidential Decree on the Concept of the Transition of the Republic of Kazakhstan to a Green Economy.[27,33,35,62,63] The latter document established targets for the gradual increase of the share of electricity generation from RES in the coming decades, including a 3 per cent share by 2020, 6 per cent by 2025, 10 per cent by 2030 and 50 per cent by 2050.[63] In pursuit of these targets, additional support measures have been introduced for projects participating in the RES auctions after 1 January 2021, including:

- Provision of financial support from the Government to the FSC, in case of non-fulfilment of its financial obligations towards RES projects. This measure was

intended to reduce the risks to investors in RES and accordingly reduce the price at auction for electricity generated by RES facilities, while also increasing the attractiveness of the RES sector in Kazakhstan to investors;
- Extension of the term of Power Purchase Agreements (PPAs) with RES producers from 15 years to 20 years, also aimed at increasing the attractiveness of the RES market to future investors and decreasing tariffs at auctions;
- Introduction of centralized purchase and sale of electric power generated by hydropower plants during the high-flow periods by the FSC, which is intended to distribute this inexpensive electric power among all consumers in the country.[64]

The adopted legislative framework and implemented mechanisms of state support have had a positive impact on RES development in the country. Between 2014 and 2020, the total installed capacity of RES in Kazakhstan increased by nearly 10 times from 178 MW in 2014 to 1,635 MW by the end of 2020 (Figure 6), with 115 power plants operating on RES, accounting for approximately 7 per cent of all installed capacity in the country.[65,66]

Figure 6. **Installed Renewable Energy Capacity by Source in Kazakhstan in 2014–2020 (MW)**



Source: Ministry of Energy[65,66]

Further plans for the development of RES in Kazakhstan include adding approximately 250 MW of RES capacity every year, with particular focus on wind and solar power development in the South and North zones of the UES RK.[66,67] The construction of RES facilities in each zone is carried out considering the resource potential, electricity demand, maximum allowable capacities and the readiness of the infrastructure. This approach ensures that additional RES capacities do not exceed the limits established for reliable operation of the UES RK.

FINANCIAL MECHANISMS FOR SMALL HYDROPOWER PROJECTS

The main sources of financing of the SHP and other RES developments in Kazakhstan are private investments and relevant investment programmes of the national and international development banks. For example, the 24.9 MW Turgusunskaya SHP-1 plant was built in the Eastern Kazakhstan region in 2016–2021 at the cost of KZT 13.39 billion (approximately USD 31.5 million), jointly funded by Kazyna Capital Management, the Kazakhstan Development Bank and the Industry Development Fund, together with private funds of the SHP developer, Turgusun-1 LLP. The engineering, procurement and construction (EPC) contractor of this SHP project was China International Water & Electric Corporation (CWE), a subsidiary of the China Three Gorges Corporation. The Turgusunskaya-1 SHP plant is the first completed project of an emerging cooperation of China and Kazakhstan in the field of hydropower, which is set to expand with construction of the Turgusunskaya-2 and Turgusunskaya-3 SHP plants.[68,69]

The European Bank for Reconstruction and Development (EBRD) has led the investment projects in Kazakhstan, with the Asian Development Bank (ADB), the Asian Infrastructure Investment Bank (AIIB) and the Eurasian Development Bank (EDB) also actively investing in RES projects in the country as well as providing effective assistance to other investors in the implementation of such projects. The United States Agency for International Development (USAID) supported the Government of Kazakhstan and RES investors in the country through the Power the Future project, which has provided support to clean energy development and regional electricity trade.[70,71,72,73]

In 2017, the Green Financial System for Kazakhstan project was established jointly by the Astana International Finance Centre (AIFC) and EBRD. Within the scope of this project, a Concept on Introduction and Development of Green Finance Instruments and Principles was outlined, providing the basis for the development of green finance in the country.[74] Subsequently, the AIFC Green Finance Centre Ltd. was established with the mission of promoting green finance in Kazakhstan and Central Asia, and supporting companies in raising green bonds at the Astana International Exchange (AIX), with the ADB beginning to issue such bonds at the exchange beginning in 2020.[75,76,77]

Feed-in tariffs (FITs) were introduced in 2013 under the Law on Supporting the Use of RES as a mechanism of RES financing.[35] However, the adopted FIT scheme had not provided sufficient benefits to make a significant impact on RES development and Kazakhstan switched from the FIT system to an auction system starting from 2018. Kazakhstan was first among the countries of Central Asia to launch RES auction bidding. The mechanism of auction bidding is aimed at selecting the most effective RES projects at the lowest prices. Kazakhstan Electricity and Power Market Operator (KOREM) JSC provides an electronic trading platform and acts as the auction organizer. The auctions have attracted significant interest from investors, with 172 companies from 12 countries participating in the bidding between 2018 and 2020.[76]

The Ministry of Energy schedules auctions for RES projects with a total capacity of approximately 250 MW in a given year. The capacity quota for SHP projects in 2021 was set at 120 MW.[77,78] A summary of SHP project selection results at RES auctions between 2018 and 2020 is provided in Table 4.

Table 4. **Results of Renewable Energy Auctions for Small Hydropower Projects in Kazakhstan in 2018–2020**

Year	*Installed capacity range*	*Installed capacity allocated for bidding (MW)*	*Installed capacity successfully auctioned (MW)*	*Number of projects selected*	*Ceiling price (KZT/kWh (USD/kWh))*	*Average auction price (KZT/kWh (USD/kWh))*	*Minimum auction price (KZT/kWh (USD/kWh))*
2018	≤10 MW	20	20.6	4	16.71 / 0.04	13.70 (0.03)	12.80 (0.03)
	>10 MW	55	61.5	3		15.08 (0.04)	14.85 (0.04)
2019	≤10 MW	15	7.0	2	15.48 / 0.04	15.45 (0.04)	15.43 (0.04)
	>10 MW	50	0	0		–	–
2020	≤10 MW	20	23.0	9	15.48 / 0.04	14.69 (0.04)	13.48 (0.03)
	>10 MW	100	0	0		–	–

Source: KOREM[78]

Developers of SHP projects approved at the RES auctions are eligible for an array of benefits, including exemption from customs duties on imported equipment, exemption from VAT on electricity sales, as well as support in the form of state in-kind grants. Additional benefits include:

- The right to conclude a PPA with the FSC for the guaranteed purchase of electric energy for a period of 15 years (or 20 years for projects approved after 1 January 2021) from the date of commissioning of the RES facility. The PPA should be based on the auction price, with annual indexation of the tariff after the first year of operation of the RES facility;
- Priority connection to the Dispatching Technological Control Centre of the electrical grids;
- Exemption from payment for services provided by electric grid companies;
- Reservation of the land plot required for construction of the RE facility.[16,64,79]
-

These benefits may be withdrawn if the developer fails to meet the deadline set in the PPA. However, the deadline may be extended provided at least 70 per cent of volume of construction has been completed. Upon commissioning, the FSC is obligated to purchase all electricity generated by the plant at the price set in the PPA. The ceiling price for SHP plants approved for auctions in 2021 was 17.87 KZT/kWh (0.04 USD/kWh).[12]

Under the Law on the Support for the Use of RES, the costs of guaranteed purchase prices used to support RES development are borne by the so-called conditional consumers, which include plants running on fossil fuels, large hydropower plants commissioned before 2016, as well as companies involved in electricity imports. The costs are allocated in proportion to the conditional consumers' electricity deliveries to the grid.[35]

The aforementioned benefits and policies have had a marked impact on the attractiveness of SHP to potential investors. In 2020, SHP proposals from investors at RES auctions exceeded the allotted capacity quota for SHP by a factor of two.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Observed impacts of climate change in Kazakhstan have included a decrease in glacier volume caused by rising temperatures. Studies have shown that intensive melting of glaciers continues in the zone of formation of the runoff of the Syrdarya and Amu Darya Rivers. In the past 50 years, the volume of glaciers has decreased by 20–40 per cent.[80]

Climate change projections for Kazakhstan predict increases in average temperature, precipitation and annual river discharge in the coming decades. Temperatures in Kazakhstan are projected to increase at a faster rate than the global average, with average annual temperature rising by 1–2 °C by 2030 and 2–3 °C by 2050, while precipitation is projected to increase by up to 10 per cent by 2050. Temperature increases are expected to further accelerate the melting of glaciers in the country. The projected high glacier melting rate is expected to cause an increase in river flow and flood risk through the middle of the 21st century. Increasing frequency of floods, mudflows and landslides is expected to exacerbate siltation and lead to the damage and possible destruction of hydropower infrastructure. In the second half of the 21st century, depletion of glaciers is projected to lead to a long-term decline in river flow and a consequent reduction of hydropower potential.[80,81,82,83]

Additionally, many rivers in Kazakhstan are transboundary, shared with neighbouring countries including Kyrgyzstan, Uzbekistan and China. Decreases in flow on these rivers have been causing shortages of water downstream and some reduction in hydropower generation in the country in recent years. The Government of Kazakhstan has been working on resolving issues related to transboundary water management by negotiating agreements with neighbouring countries and taking part in international and regional water management programmes, including the World Bank-sponsored Climate Adaptation and Mitigation Programme for the Aral Sea Basin.[84,85,86,87,88]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The development of SHP plants in Kazakhstan is hindered by several factors:

- The electricity sector in the country is dominated by cheap thermal power plants due to the vast availability of domestic fossil fuel reserves. Thermal power generation is furthermore subsidized by the Government and actively defended by thermal power producers against competition from RES;
- The power distribution infrastructure in the country is largely out of date. It is unable to accommodate significant additional SHP capacity without major upgrades;
- The installed capacity quotas for SHP projects included in the RES auctions are low and much smaller than requested by potential investors. This is mostly due to the restrictions imposed by the outdated power distribution infrastructure, but also due to the RES development policy in the country, which gives preference to wind and solar power;
- The initial investment costs are high due to reliance on imports;
- Long-term funding opportunities are limited;
- The absence of a programme or clear strategy for SHP development in the country beyond 2030 is creating uncertainty for potential investors;
- There is a shortage of up-to-date scientific data on SHP potential in the country;
- There is a lack of qualified and experienced professionals in the SHP development sector of Kazakhstan, particularly those with a good understanding of the integration of SHP with power infrastructure.

Despite the existing obstacles, the outlook for SHP development in the country is positive due to several enablers introduced by the Government for the RES projects, including:

- The regulatory framework in Kazakhstan is strongly supportive of RES development in the country as a whole and provides investors with significant incentives, including customs and tax waivers, waivers of grid connection fees, guaranteed purchase prices and periods and in-kind aid;
- The Energy Ministry of Kazakhstan has outlined, and is in the process of implementing, strategic plans with clear targets for RES development, including the construction of significant additional SHP capacities.

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Kyrgyzstan

Eleonora Kazakova, Chair of the Association of Renewable Energy Sources in the Kyrgyz Republic

KEY FACTS

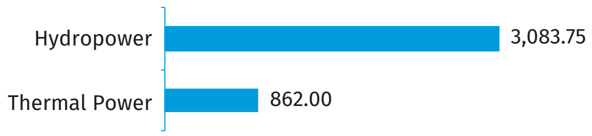
Population	6,523,500 (2020)[1]
Area	199,990 km^2 [2]
Topography	The topography of the Kyrgyz Republic is dominated by the Tien Shan and the Pamir-Alai Mountain Range systems. The highest point is Pobeda Peak (7,439 metres) and the lowest point lies at 480 metres above sea level at the transboundary crossing of the Naryn River on the border with Uzbekistan. Approximately 93 per cent of the country's area is above 1,000 metres, 85 per cent is above 1,500 metres and 42 per cent is above 3,000 metres above sea level.[3]
Climate	A total of four climatic regions can be distinguished on the territory of the Kyrgyz Republic: the Inner Tien Shan, the north-eastern, the north-western and the south-western regions. The climate is sharply continental. Summers in the cities are quite hot, but relatively cool in the mountains. Winters are cold and snowy, especially in the highlands. The average summer temperature in Kyrgyzstan is 27 °C, with average minimum and maximum temperatures of 16 °C and 33 °C, respectively. Winter temperatures average 1 °C, with average minimums and maximums of -12 °C and +10 °C, respectively.[1]
Climate Change	Between 1885 and 2010, temperatures in the Kyrgyz Republic have increased significantly. Moreover, the rate of change has not been linear and has also increased significantly over the past decades. The rate of increase of the average annual temperature in the country was 0.0104 °C per year for the entire observation period. However, over the period from 1960 to 2010, it has more than doubled to 0.0248 °C per year and in the last 20 years (1990-2010) it reached 0.0701 °C per year. The increase in the average annual temperature is almost the same across all climatic zones and regions of the country, except for the Issyk-Kul region. Projections of current temperature trends to 2100 indicate that temperatures in all regions may increase by more than 4 °C, relative to the baseline period 1961–1990.[4,5]
Rain Pattern	Kyrgyzstan receives highly variable amounts of annual precipitation depending on the region and elevation. The largest precipitation volumes are typically observed along the south-eastern slopes of the Fergana Range (1,000 mm), with the Kyrgyz and Chatkal Ranges receiving somewhat less (700–900 mm). A moderate amount falls on the valleys and foothills of the Osh region (300–700 mm) and the Talass and Chuy Valleys (250–500 mm). The lowest precipitation amounts are observed in Inner and Central Tian Shan (200–300 mm), as well as on the western shores of Lake Issyk-Kul (164 mm).[6]
Hydrology	The water resources of Kyrgyzstan include approximately 50 billion m^3 per year of surface runoff from mountain rivers, 13 billion m^3 of potential groundwater reserves, 1,745 billion m^3 of lake water and 650 billion m^3 stored in glaciers. There are 1,923 lakes in Kyrgyzstan, of which the largest are Issyk-Kul, Son-Kul and Chatyr-Kul. Issyk-Kul alone contains approximately 1,731 km^3, or over 99 per cent of all lake water in the country. The mountainous terrain of the republic has led to the formation of a branched river network, with more than 3,500 rivers and streams, of which the longest are the Naryn (807 km), Chu (380 km) and Talas (200 km) Rivers.[2]

ELECTRICITY SECTOR OVERVIEW

The electricity sector in Kyrgyzstan is characterized by several ongoing issues, including the aging of electricity infrastructure, technical losses, electricity tariffs below the cost of production, financial losses and limitations stemming from the interdependence of water discharge and electricity production. All these factors contribute to a decrease in the reliability of the electricity supply to consumers. Additionally, the country is heavily dependent on fossil fuel imports, with domestically-supplied oil and natural gas products accounting for only approximately 5 per cent of total demand.[7]

The total installed capacity of Kyrgyzstan in 2019 stood at approximately 3,946 MW, provided by 7 large hydropower plants (3,030 MW), 18 small hydropower (SHP) plants (54 MW) and 2 thermal plants (862 MW) (Figure 1). Overall, hydropower accounted for approximately 78 per cent of installed capacity and thermal power for the remaining 22 per cent (Figure 2).[8,9,10,11]

Figure 1. **Installed Electricity Capacity by Source in Kyrgyzstan in 2019 (MW).**



Source: GKPEN,[8,9] Tazabek News Agency,[10] Kazakova[11]

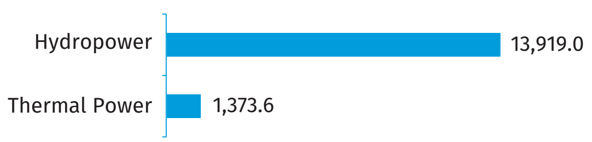
All large hydropower plants and thermal plants in Kyrgyzstan, representing a total installed capacity of 3,892 MW (nearly 99 per cent of the total national installed capacity) and a multi-year average annual generation of 13,478 GWh, are operated by Electric Stations OJSC (Table 1).[8] The installed capacity of the country has recently increased with the commissioning in 2017 of two new power blocks on the Bishkek thermal power plant with a total capacity of 300 MW, as well as two new SHP plants in the Issyk-Kul region with a total capacity of 7 MW.[10,12]

Table 1. **List of Power Plants Operated by Electric Stations OJSC**

Name	*Installed capacity (MW)*	*Average annual generation (GWh)*	*Reservoir volume (m^3)*	*Launch year*
Toktogul HPP	1,200	4,400	19,500.0	1975
Kurpsay HPP	800	2,630	370.0	1982
Tashkumyr HPP	450	1,698	144.0	1987
Shamaldysay HPP	240	902	41.0	1995
Uch-Kurgan HPP	180	820	52.3	1962
Kambarata HPP	120	1,141	70.0	2010
At-Bashy HPP	40	147	9.6	1970
Total hydropower	3,030	11,738	20,186.9	
Bishkek HPP	812	1,740	-	1961
Osh HPP	50	-	-	1966
Total thermal power	862	1,740	-	
Total	3,892	13,478	20,186.9	

Source: GKPEN[8]

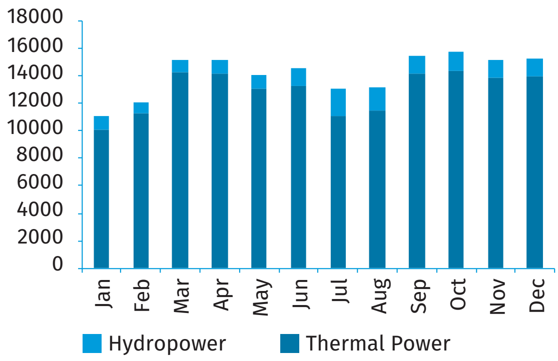
Figure 2. **Annual Electricity Generation by Source in Kyrgyzstan in 2020 (GWh)**



Source: National Statistical Committee[13]

In 2020, electricity generation in Kyrgyzstan amounted to 15,292.6 GWh, with hydropower accounting for 13,919 GWh (91 per cent of the total) and thermal power for 1,373.6 GWh (9 per cent) (Figure 2). Total generation has been fairly stable since 2011, although the relative contributions of hydropower and thermal power have fluctuated from year to year (Figure 3).[13]

Figure 3. **Annual Electricity Generation by Source in Kyrgyzstan in 2009–2020 (GWh)**



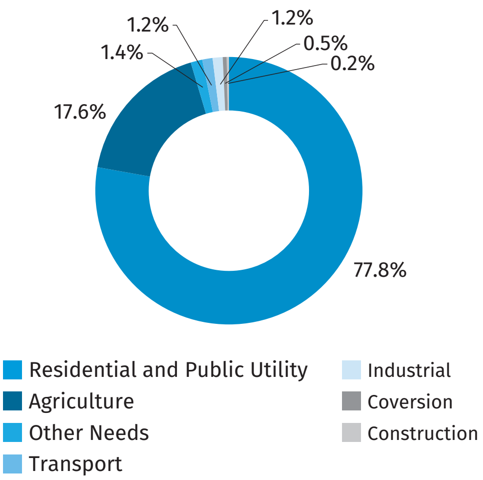
Source: National Statistical Committee[13]

A peculiarity of the energy system of Kyrgyzstan is that 90 per cent of the generating capacity comes from hydropower plants located in the south of the country, while 70 per cent of electricity consumption is concentrated in the north. During the winter, the existing capacity of hydropower plants generally cannot fully satisfy electricity demand and thermal power provides the difference. During the summer, in part due to additional runoff from mountain glaciers, the supply of electricity exceeds demand. At the same time, there is significant demand for irrigation water especially in the downstream areas of major rivers, which competes with water demand from hydropower. Moreover, the shared use of water resources in the Syr Darya basin by Kyrgyzstan, Uzbekistan, Tajikistan and Kazakhstan currently creates water management difficulties and is not sustainable.[14] Instability of generation from hydropower, observed in 2008–2009 and again in 2014–15 and stemming from insufficient runoff, has caused Kyrgyzstan to rely on increased electricity imports.[15]

Domestic consumption of electricity in 2019 amounted to 12,600 GWh (over 83 per cent of all generated electricity for that year). Imports and exports were almost equal, at 269 GWh and 271 GWh, respectively, while losses amounted to 2,514 GWh (nearly 17 per cent of generation).[15,16] Such high losses, reaching 19 per cent in previous years, are explained by aging electrical equipment and the lagging pace of reconstruction and modernization of power grids compared to the growth of electricity consumption. The equipment overload and increased accident rate significantly reduce the efficiency and reliability of the electricity supply in Kyrgyzstan, especially during the fall and winter periods. As a consequence, although electricity access in the country is nominally 100 per cent (with the exception of some remote areas typically inhabited on a seasonal basis), only 76 per cent of consumers (nearly 89 per cent in the city, but 69 per cent in the countryside) have stable access to electricity.[17]

Consumption of electricity in 2019 was dominated by the residential and public utilities sector (78 per cent), followed by industry (nearly 18 per cent), with agriculture, construction, conversion to other forms of energy and transport making up the remainder (over 4 per cent) (Figure 4).[15] Consumption by the residential sector in particular has been on the rise, driven by the very low cost of electric energy relative to the cost of fossil fuels, the prices for which have been fluctuating in parallel with global market trends.

Figure 4. **Share of Electricity Consumption by Sector in Kyrgyzstan in 2019 (%)**



Source: National Statistical Committee[15]

The power grid of the Kyrgyz Republic includes 110–500 kV transmission lines with a total length of 6,683 kilometres, including 541 kilometres of 500 kV lines, 1,748 kilometres of 220 kV lines, 4,353 kilometres of 110 kV lines and 41 kilometres of 35 kV lines (on lease). The grid also includes 190 substations of 110 kV and above with a total capacity of 8,929.2 MVA, including 2 500 kV substations with a total capacity of 1,829 MVA, 14 220 kV substations with a capacity of 2,902 MVA and 174 110 kV substations with a capacity of 4,188.2 MVA. Intersystem connections of 220–500 kV exist with the power systems of Kazakhstan, Tajikistan and Uzbekistan.[18]

In 2001, with the aim of ensuring the effective functioning of the electricity sector, the unified vertically integrated energy system represented by the state-owned JSC Kyrgyzenergo was reorganized and several energy joint stock companies were established by type of activity — generation, transmission and distribution of electricity and heat, with a state ownership share of over 93 per cent.[19] In addition, a programme of privatization in the energy sector was adopted, under which it became possible to privatize SHP plants up to 30 MW.[20]

However, in 2016, the country essentially returned to the model of a vertically integrated market that existed prior to 2001. Recognizing that the operation of the energy sector under the distributed model was inefficient and the fact that energy companies are natural monopolies, the Government decided to create the state company National Energy Holding Company OJSC (NEHK OJSC). This management company again united all the major market participants in the electric power industry: two electric power generation companies, a transmission system operator, four distribution companies and one heating provider.[21]

Electric power generation is mainly provided by the Electric Stations OJSC, which operates nearly all power plants in the country with the exception of some SHP plants. Transmission of electric power through 500/220/110 kV networks is carried out by the National Electric Grid of Kyrgyzstan OJSC (NESK OJSC). Four regional electricity distribution companies are responsible for distributing electricity to end users through 35/10/6/0.4 kV networks: Severelectro OJSC (Bishkek, Chui and Talas regions), Jalalabadelektro OJSC (Jalal-Abad region), Oshelektro OJSC (Osh region) and Vostokelektro OJSC (Issyk-Kul region). In August 2018, Kyrgyz Energy Settlement Center OJSC (KERT JSC) was established to centralize information on electricity flows and losses, publish balance data and perform calculations for all market participants. All of the aforementioned enterprises are included in and are subsidiaries of NEHK OJSC.[22] The purchase, resale and delivery of electricity to end users is also performed by a number of private wholesale electricity buyers and sellers (WPCs) that own or lease transmission lines and substations. In total, 123 companies are licensed to sell electricity, 19 to transmit and 107 to distribute.[23,24]

Prior to 2021, the electric power industry was regulated by the State Property Management Fund (FUGI) and three authorized energy agencies:

- The State Committee for Industry, Energy and Subsoil Use (GKPEN), established in 2016 and performing the functions of formulating and implementing state policy in the energy sector;
- The State Inspectorate for Environmental and Technical Safety (GIETB), ensuring the technical safety, reliability and continuity of generation, transmission, distribution and consumption of electricity, heat and natural gas, as well as the efficiency of their use;
- The State Agency for Regulation of the Fuel and Energy Complex (GARTEK), an authorized anti-monopoly state body that regulates the activities of fuel and energy complex entities through licensing and tariff setting for electricity, heat and natural gas.[25,26,27]

As part of the reforms of state agencies in the Kyrgyz Republic implemented in 2021-2022, GKPEN was transformed into the Ministry of Energy and absorbed both GIETB and GARTEK, with the latter transformed from an independent agency into the Department for Regulation of the Fuel and Energy Complex under the Ministry of Energy. The Ministry of Energy also gained control of 100 per cent of the shares of NEHK, while FUGI was incorporated into the structure of the Ministry of Economy. NEHK remains the managing company of the large state-owned joint-stock energy companies, which in turn, were enlarged, with the NESK OJSC joined with the four regional distribution companies to form a single national grid company, and the Electric Stations OJSC absorbing the heat provider Bishkekteploset OJSC. Consequently, the energy sector is now fully managed by the Ministry of Energy, Electric Stations OJSC is responsible for electricity generation as well as the production, transmission and distribution of heat energy, while NESK OJSC is responsible for the transmission and distribution of electricity.[11,28,29]

GARTEK is officially responsible for calculating and setting energy tariffs. At the same time, tariffs, for generation and for end users, have not been able to cover all costs, leading to a chronic shortage of financial resources needed to invest in the restoration of worn-out assets of the energy system.[30]

Tariff policy in Kyrgyzstan is implemented in accordance with Law of the Kyrgyz Republic No. 56 from 30 October 1996 ("On energy"), Law No. 8 from 28 January 1997 ("On the electric energy sector") and various government resolutions through developing a medium-term tariff policy for electricity and heat (MTTP), which presupposes the gradual elevation of tariffs to cover rising costs. However, the electricity tariff policy is also subject to political considerations, and in practice tariffs for households were frozen between 2014-2017 out of consideration for the economic well-being of low-income households.[27,31]

The MTTP for the years 2020–2022 has essentially retained tariff rates at levels established by the MTTP for 2014–2017, with minor changes to the definition of consumer categories that now include certain institutions for children and the disabled, as well as two consumer categories emerging as a result of recent technological shifts — electric transport and facilities for the mining of cryptocurrencies (Table 2).[32,33,34]

One consequence of the low electricity tariffs is that Kyrgyzstan has trouble attracting private investment in the electric energy sector. Therefore, most major investment projects in the sector are financed by international partners. These have included projects on the modernization of the Toktogul cascade of hydropower plants, as well as the launch of the second hydropower unit at the Kambarata-2 hydropower plant, reconstruction of the At-Bashy hydropower plant and the modernization of the Bishkek thermal power plant. Additional recently completed projects have included power grid upgrades, the construction of additional 500 kV lines and substations and the ongoing "CASA-1,000" Central Asia–South Asia Energy Project, connecting the Kyrgyz Republic and Tajikistan with countries experiencing power shortages, including Afghanistan and Pakistan.[14]

The fuel and energy policy of Kyrgyzstan and its development strategy is implemented in accordance with the National Energy Programme for the period 2008–2010 and the Development Strategy of the Fuel and Energy Complex until 2025 (Resolution of Supreme Council of the Kyrgyz Republic No. 346-IV from 24 April 2008), the Medium-Term Strategy of Electric Power Development of the Kyrgyz Republic for 2012–2017 (Government Decree No. 330 of 28 May 2012), the National Strategy for Sustainable Development of the Kyrgyz Republic for 2013–2017 (Presidential Decree from 21 January 2013) and the Programme of Transition of the Kyrgyz Republic to Sustainable Development for 2013–2017 (Decree of the Government of the Kyrgyz Republic No. 218 from 30 April 2013). In 2018, GKPEN developed and submitted for discussion a draft Framework for the Development of the Fuel and Energy Complex of the Kyrgyz Republic until 2040. The framework defines the goals, priorities and key objectives of the country's energy sector development to 2040, as well as policy mechanisms that will ensure the achievement of these goals.[36] Additionally, having joined the Eurasian Economic Union (EAEU) in 2015, Kyrgyzstan is also expected to participate in the emerging Common Energy Market of the EAEU and is in the process of amending its legislation to include regulations on the development of international electricity networks, trade in the Common Energy Market trade, rules for determining and distributing the capacity of interstate power lines, information exchange and unified rules on access to services of natural monopolies in the field of electric power.[37]

Table 2. **Electricity Tariffs as per MTTP for 2014–2017, 2021–2022**

	Consumer category	*As of Dec. 2017*		*As of Oct. 2021*	
		KGS/ kWh	*USD/ kWh*	*KGS/ kWh*	*USD/ kWh*
1	General population:				
1.1	Consumption up to 700 kWh/ month	0.770	0.011	0.770	0.009
1.2	Consumption greater than 700 kWh/month	2.160	0.031	2.160	0.025
2	Residents of highland and other remote areas:				
2.1	Consumption up to 1000 kWh/ month	0.770	0.011	0.770	0.009
2.2	Consumption greater than 1000 kWh/month	2.160	0.031		
3	Socially-vulnerable households:				
3.1	Consumption up to 700 kWh/ month			0.500	0.006
3.2	Consumption greater than 700 kWh/month			2.160	0.025
4	Pumping stations	0.779	0.011	1.090	0.013
5	Electric transport			1.680	0.020
6	Social institutions for children of the boarding school type, institutions for disabled and/or senior citizens			1.680	0.020
7	Publically-funded entities, industry, agriculture, and others	2.240	0.032	2.520	0.030
8	Entities engaged in mining of cryptocurrencies, gold processing facilities, alcohol production facilities			5.040	0.059
9	Foundries			3.780	0.045
10	Cement plants			3.280	0.039

Source: GARTEK,[32,35]

Note: Exchange rate of KGS to USD: 69.7 KGS/USD in December 2017, 82.8 KGS/USD in December 2020.

SMALL HYDROPOWER SECTOR OVERVIEW

In accordance with Law of the Kyrgyz Republic No. 283 from 31 December 2008 ("On Renewable Energy Sources"), SHP plants are defined as hydropower plants with capacity up to 30 MW.[38] At the same time, as of 2021 there were no SHP plants of above 10 MW capacity in the country and SHP plants in the 10–30 MW range exist only as hypothetical projects.

As of 2020, there were 18 SHP plants operational in the country, with a total installed capacity of 53.75 MW and generating approximately 197.9 GWh in 2020. Of these, nine plants with a total installed capacity of 38.4 MW, are operated by the Chakan HPP OJSC, a subsidiary of NEHK with a government stake of over 93 per cent, while the rest are operated by private companies (Tables 3 and 4).[9,10,39]

Table 3. **List of Existing Public Small Hydropower Plants in Kyrgyzstan**

Name	*Location*	*Capacity (MW)*	*Head*	*Type of Plant*	*Operator*	*Launch year*
Alamedinskaya 6	Grand Chuy canal	6.4	15.0	Run-of-river	"Chakan HPP" OJSC	1958
Alamedinskaya 5	Grand Chuy canal	6.4	15.0	Run-of-river	"Chakan HPP" OJSC	1957
Bystrovskaya	Chu River	8.7	26.3	Run-of-river	"Chakan HPP" OJSC	1954
Alamedinskaya 4	Grand Chuy canal	2.1	12.0	Run-of-river	"Chakan HPP" OJSC	1952
Alamedinskaya 3	Grand Chuy canal	2.1	12.0	Run-of-river	"Chakan HPP" OJSC	1951
Lebedinovskaya	Grand Chuy canal	7.6	28.6	Run-of-river	"Chakan HPP" OJSC	1948
Alamedinskaya 2	Grand Chuy canal	2.5	12.0	Run-of-river	"Chakan HPP" OJSC	1948
Alamedinskaya 1	Grand Chuy canal	2.2	11.8	Run-of-river	"Chakan HPP" OJSC	1945
Malaya HPP	Grand Chuy canal	0.4	10.0	Run-of-river	"Chakan HPP" OJSC	1929

Source: GKPEN,[9] Kyrgyz Energy Settlement Center[39]

The total hydropower potential of the republic is estimated at 28.83 GW in capacity and 245.52 TWh in annual gross power generation.[2] However, estimates for potential SHP capacity in Kyrgyzstan have varied widely, from 180 MW to 900 MW. In 2017, a World Bank meta-study estimated the total SHP potential in the country to be on the order of 409 MW, including both existing plants and undeveloped potential sites. The meta-study was based on the results of several prior studies, including an assessment sponsored by the United Nations Development Programme (UNDP) and conducted in 2015 which identified 63 undeveloped potential sites with a total estimated capacity of 258 MW.[40] The latter figure is cited in recent official documents of the Kyrgyz Republic as the estimate of undeveloped SHP potential, including the GKPEN database of potential SHP sites.[41,42,43] Going by this figure, the total SHP potential capacity of the country including already existing plants is approximately 311.8 MW.

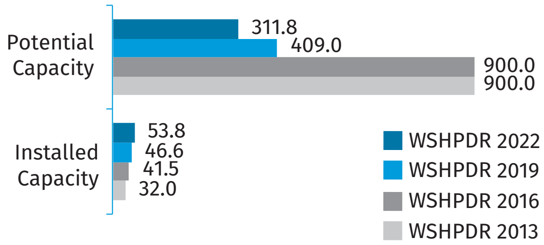
Table 4. **List of Existing Private Small Hydropower Plants in Kyrgyzstan**

Name	*Location*	*Capacity (MW)*	*Head*	*Type of Plant*	*Operator*	*Launch year*
Konur-Olon-skaya	Konur-Olon River	3.6	480.0	Run-of-river	"Konur-Olonskaya HPP" LLC	2019
Kok-Sayskaya	Kok-Say River	3.4	486.0	Run-of-river	"Kok-Sayskaya HPP" LLC	2019
Tegermenti-nskaya	Tegermenty River	3.0	200.0	Run-of-river	"Tegermenty HPP" LLC	2016
Kyrgyz-Ata SHPP	Kyrgyz-Ata River	0.3	30.0	Run-of-river	"Sattelit-2005" OJSC	2016
Maryam SHPP	Ak-Suu River	0.5	34.0	Run-of-river	Maryam Agricultural Cooperative	2015
Issyk-Atynskaya	Issyk-Ata River	1.6	70.0	Run-of-river	"ARK Construction Firm" LLC	2008
Naimanskaya	Naiman River	0.6	24.0	Run-of-river	"Naiman HPP" OJSC	2005
Kalininskaya	Karabalta River	1.4	60.0	Run-of-river	"Kalininskaya HPP" LLC	1998
Dzhidalik SHPP	Shahimardan River	1.0	12.0	Run-of-river	"Kadamdzhay Antimony Plant" OJSC	1948

Source: GKPEN,[9] Tazabek News Agency,[10] Kyrgyz Energy Settlement Center[39]

Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity of SHP in Kyrgyzstan has increased by over 15 per cent, due to the commissioning of the Kok-Sayskaya and the Konur-Olonskaya SHP plants in 2019. Meanwhile, potential capacity has decreased by nearly 24 per cent due to the availability of more accurate data on official estimates (Figure 5).[44] A partial list of potential sites is displayed in Table 5.

Figure 5. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Kyrgyzstan (MW)**



Source: GKPEN,[9] Tazabek News Agency,[10] Kyrgyz Energy Settlement Center,[39] Open Data Kyrgyzstan,[42] *WSHPDR 2019*,[44] *WSHPDR 2013*,[45] *WSHPDR 2016*[46]

Table 5. **List of Selected Potential Small Hydropower Sites in Kyrgyzstan**

Name	*Location*	*Potential capacity (MW)*	*Head*	*Type of site (new/refurbishment)*
N/A	Chandalash River	10	160	New
N/A	Chon-Aksuu River	11	260	New
N/A	Naryn River	12	24	New
N/A	Kara-Suu River (left)	14	140	New
N/A	Otro-Tokoyskoye reservoir	26	35	New

Source: Open Data Kyrgyzstan[42]

Active construction of SHP plants in Kyrgyzstan was carried out between 1913 and 1963 and reached its peak at the end of the 1950s. Most SHP plants of the period were attached to large enterprises such as factories or collective farms and were often characterized by low technical and economic indicators. In the 1960s, in connection with the mass transition to centralized power supply and the construction of a cascade of large hydropower plants in the south of the country, the further operation of SHP plants was considered inexpedient. Some of them were written off and dismantled, while the rest were transferred to the company Kyrgyzenergoholding. Subsequently, the least economically-efficient SHP plants were mothballed.[47]

In the last two decades, several programmes have been adopted by the Government of the Kyrgyz Republic to promote SHP development, including the Programme for the Development of Small and Medium Electric Power to 2012, National Energy Programme of the Kyrgyz Republic to 2025 and the Green Economy Framework of the Kyrgyz Republic adopted in 2018. These programmes variously stipulated the construction of an additional 41 SHP plants and a total additional SHP capacity of 178 MW to be reached through the refurbishment of abandoned plants, upgrades to operational plants as well as the construction of new plants. However, these ambitious goals have not been realized so far, owing to institutional, technical and financial obstacles, with the few completed projects having largely been financed by international or bilateral donors.[11] For example, the Kok-Sayskaya and the Konur-Olonskaya SHP plants spent over a year in legal limbo following construction before their output was finally cleared for the national grid.[10,39]

RENEWABLE ENERGY POLICY

Kyrgyzstan is endowed with significant potential for unconventional and renewable energy sources (RES), which can be used to increase the country's energy self-sufficiency. RES available in Kyrgyzstan, which include substantial wind, water, solar and biomass potential, can theoretically cover more than 50 per cent of the country's energy needs. At the same time, the technically-feasible capacity to date is at approximately 20 per cent of the overall potential capacity, only 6 per cent is economically feasible and the practical implementation stands at less than 2 per cent.[48] The ratification by Kyrgyzstan of the Charter of the International Renewable Energy Association (IRENA) in January 2021 is expected to expand the range of cooperation and exchange of experience with other countries in the development of RES in the country, the introduction of advanced technologies and attraction of investment in the field of RES.[49]

Legislation regulating the RES sector in Kyrgyzstan includes the Laws of the Kyrgyz Republic "On Energy", "On Electricity", "On Energy Efficiency", "On RES" and "On Licensing and Permitting System in the Kyrgyz Republic".[50] The Law "On RES", passed on 31 December 2008, has since been amended several times. A major obstacle contained in previous revisions had been the excessive burden placed on distribution companies in purchasing electricity from RES. Recent changes to the law, adopted in July 2019, included:

- Compensation of the additional expenses of distribution companies for purchase of electric power generated with the use of RES, which will now be taken into account when calculating and setting national tariffs on electric power for final consumers;
- Revision of the multiplying coefficients for the maximum tariff at which electricity from RES will be purchased, currently set at 1.3 for all types of RES;
- Introduction of quotas for the total amount of electric capacity of RES installations by region and by type of RES, which will be able to receive an increased tariff for 10 years;
- Definition of the tariff for RES installations built outside the quota as the rate of maximum effective tariff minus the cost of transit to the distribution companies;
- Mandating the purchase of electricity from RES by the distribution companies.[51]

Additionally, the Tax Code has been revised to include a tax exemption on profits from the sale of electricity and heat produced using RES for a period of five years from the start of operation of an RES facility and an exemption from VAT on the import of RES equipment.[52]

In accordance with these legislative changes, in December

2020 the state tariff regulator GARTEK issued a single-tariff system for electricity from RES for facilities constructed under the RES quota, as well as for those constructed outside the quota, to stay in effect for a period of 10 years. For RES facilities built under the quota, the final tariff is a product of the maximum allowed tariffs for the final consumer and the multiplying coefficient. In December 2020, it equalled 2.91 KGS/kWh (0.035 USD/kWh). For those outside the quota, the tariff is determined individually based on the cost of transit of the local distribution company.[32,53]

SMALL HYDROPOWER LEGISLATION AND REGULATIONS

The construction of and generation of electricity by SHP plants in Kyrgyzstan is regulated by Resolution of the Government of the Kyrgyz Republic No. 525 from 30 October 2020, "Regulations on the conditions and procedures for the generation and supply of electricity using renewable energy sources". The regulation replaced previous legislation including the 2017 laws "On the Adoption of the Regulations on Tenders for Construction Rights for Small Hydropower in the Kyrgyz Republic" and amendment to it.[54,55,56] The resolution determines the conditions and procedure of generating and supplying electricity using RES, regulates the legal regimes for generating and supplying electricity using RES within established quotas, outside quotas, on a contractual basis and for own needs, as well as determines the range of entities involved in the process of generating and supplying electricity.[54]

COST OF SMALL HYDROPOWER DEVELOPMENT

Average capital cost estimates for construction of SHP plants at surveyed sites have varied widely. The 2017 World Bank report compiled an overview of the results of several prior studies conducted by a number of government and private agencies between 2006 and 2015, with average capital costs ranging between 1,107 USD/kWh and 3,958 USD/kWh. In terms of specific sites, costs were sometimes drastically different depending on whether peripheral development such as network connections and road construction were included. For example, a survey of the Oi-Alma SHPP-2 potential site conducted in 2011 by AF-Mercados EMI estimated a construction cost of 1,409 USD/kWh without peripheral development and 2,383 USD/kWh including peripheral development. Similarly, development of the Orto-Tokoi Dam SHP site was estimated at 770 USD/kWh without peripheral development and at 1,252 USD/kWh with peripheral development included.[40]

Electricity generated by SHP plants in Kyrgyzstan produces energy savings at the Toktogul hydropower cascade and, in turn, eliminates the need to operate the Bishkek thermal power plant or import electricity. Furthermore, SHP plants could be useful to help maintain the water level of the Toktogul Reservoir in a state of readiness to cover additional hours of peak consumption in winter time. Essentially, the economic benefit of operating an SHP plant in Kyrgyzstan is equal to the difference between the cost of operating that plant and the costs of operating the Bishkek thermal power plant, the power plant acting as a marginal price setter, with the highest cost of electricity generation in the country.[40] In 2019, the average cost of electricity production at the Bishkek thermal power plant was 3.58 KGS/kWh ($0.032 USD/kWh).[57] Thus, the Government of Kyrgyzstan has every reason to encourage the development of all SHP sites whose economic cost of generation is below this threshold.

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Projected climate change in Kyrgyzstan is expected to lead to a decrease in hydropower potential, so adaptation and mitigation measures are necessary. For example, expected climate change after the 2030s will lead to changes in water flows and a reduction in the potential of hydropower resources. One significant consequence of the temperature increase is the expected reduction in the duration of the heating period, by 16 per cent by 2050 and by more than 30 per cent by 2080.[4] As a result, an annual Gross Domestic Product (GDP) growth of even 4 per cent would result in the exhaustion of the hydropower potential in Kyrgyzstan within a few decades. This may mean that the development of small and micro-hydropower plants, which in the short term may help to mitigate energy shortages, particularly in remote areas, in the long term may prove unsustainable.[5]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

In the absence of state funding for projects to build SHP plants, Kyrgyzstan is in need of ensuring conditions that would attract capital from private investors, as well as concessional loan financing from international financial institutions. At the moment, the most significant barriers and risk factors deterring additional investment in the SHP sector in Kyrgyzstan include the following:

- Natural risks including, siltation, flooding, and bank erosion, potential seismic risk, severe winter weather including ice drift and seasonal instability in water availability;
- Instability in the country's political system, frequent changes in state leadership and the composition of government bodies, corruption in government bodies, including the courts, which investors face when applying to authorized bodies or participating in court hearings;
- Ineffectiveness of the ongoing reforms in the energy sector, lack of a strategic vision for RES development, lack of a government body responsible for RES development, overlapping functions of authorized bodies and lack of an interagency unified approach to RES

development;
- Legal obstacles including the absence of a “water right” concept in the water legislation, difficulties with land allocation, and the lack of hydrological and land cadastral data for regional planning;
- Shortage of state funds and high external debts of the energy sector;
- Shortage of qualified engineering and operational staff in the SHP sector;
- Low demand for alternative energy sources from the general population due to highly subsidized electricity, and lack of environmental awareness;
- Lack of detailed studies of SHP potential and modern best practices in SHP development and operation, as well as a lack of public outreach on the advantages of small-scale power generating facilities.[58,59,60]

Factors beneficial to the development of SHP in Kyrgyzstan include:
- Large untapped SHP potential;
- Available data developed through prior feasibility studies on potential SHP sites and their cost of development;
- Existing framework of preferential tariffs and quotas for RES including SHP;
- The high cost of producing electricity at the Bishkek thermal power plant that creates a need for alternative energy sources.

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Tajikistan

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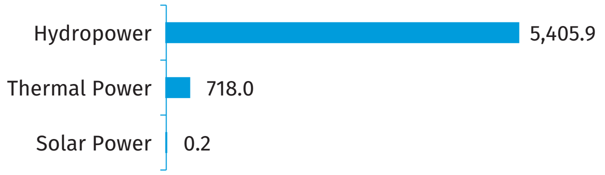
KEY FACTS

Population	9,506,000 (2021)[1]
Area	141,400 km² [1]
Topography	Tajikistan is a mountainous country with elevations ranging from 320 metres to 7,495 metres. Ninety-three per cent of the country's territory is covered with mountains, with the Turkestan, Zeravshan, Gissar and Alai Ranges in the north-western and central parts of the country and the Pamir Range in the south-east. Major valleys include the Fergana Valley in the north as well as the Vakhsh and Gissar Valleys in the south-west. The highest point in the country is Ismail Somoni Peak at 7,495 metres.[2]
Climate	The climate in Tajikistan is subtropical, sharply continental and dry, with significant daily and seasonal variations in air temperature. January temperatures range from 22 °C in Panj to -63 °C at Lake Bulunkul in the Gorno-Badakhshan Autonomous Region (GBAO), while July temperatures range from 48 °C (Lower Panj) to -8 °C (Lake Bulunkul). The country receives between 2,100 and 3,170 hours of sunshine per year.[3,4]
Climate Change	Between 1936 and 2014, average annual temperatures increased by 0.1–0.2 °C per decade in the lowlands, by 0.3–0.5 °C per decade at elevations of 1,000–2,500 metres and by 0.2–0.4 °C per decade at elevations above 2,500 metres. An increase in extreme temperatures has also been observed between 1940 and 2005. Climate change projections predict an increase in average annual temperatures of 0.2–0.4 °C by 2030 across all areas of the country, relative to the 1961–1990 baseline period. This is consistent with observed trends over the past 15–20 years. By the end of the 21st century, an increase of up to 5 °C is expected in the southern parts of the country as well as in mountainous areas.[3,4]
Rain Pattern	The average annual amount of precipitation in Tajikistan varies from 273 mm/year to 514 mm/year, averaging 400 mm/year over the last 20 years. However, there is significant regional disparity in rainfall, with the Fedchenko Glacier averaging 2,236 mm/year, while the Ferghana Depression receives only 100 mm. The Eastern Pamirs experience an extreme lack of precipitation, receiving almost no snow or rain.[2,5]
Hydrology	There are more than 25,000 rivers in Tajikistan with a total length of 69,200 km. Of these, 947 rivers are 10–100 km long, 16 rivers are 100–500 km long and 4 rivers are longer than 500 km. The average total annual flow of all rivers in the country is approximately 64 km³, with average runoff from one square kilometre four times higher than the average for the Central Asia region. A significant part of the surface flow in Tajikistan is fed by glaciers and snowmelt. There are between 8,000 and 14,500 glaciers in Tajikistan, covering 6-8 per cent of the territory of the country. The number of glaciers has been fluctuating as climate change has fractured larger glaciers into multiple smaller ones. The share of glacier discharge in total annual flow of rivers of Tajikistan is 13 km³. Tajikistan contains approximately 1,300 lakes with a total area of 705 km² in additional to 11 artificial reservoirs with a total area of 664 km² and a total volume of 15.3 km³.[6,7,8]

ELECTRICITY SECTOR OVERVIEW

The electricity sector of Tajikistan is dominated by the state-owned Barki Tojik, which operates electric energy infrastructure across the entire country with the exception of the GBAO, a geographically and topographically isolated region in the east part of the country. The private-public company Pamir Energy is the primary power supplier in the GBAO. The total installed capacity of Tajikistan was 6,124.1 MW in 2021, including 6,054.4 MW operated by Barki Tojik, 44.8 MW operated by Pamir Energy, with the remaining 24.9 MW accounted for by small hydropower (SHP) plants operated by independent power producers (IIPs). Hydropower provided 5,405.9 MW (88 per cent) of the total installed capacity, while thermal power provided 718.0 MW (12 per cent) and solar power provided 0.2 MW (less than 1 per cent) (Figure 1).[9]

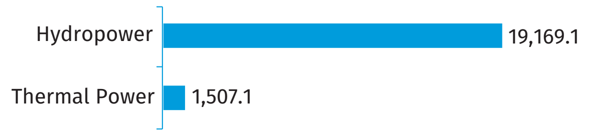
Figure 1. **Installed Electricity Capacity by Source in Tajikistan in 2021 (MW)**



Source: MEWR[9]

Electricity generation in 2019 amounted to 20,676.2 GWh, of which hydropower provided 19,169.1 GWh (93 per cent) and thermal power 1,507.1 GWh (7 per cent), while generation from solar power was negligible (Figure 2).[1] Exports of electricity to Afghanistan, Uzbekistan and Kyrgyzstan amounted to 1,528.4 GWh in 2020, having decreased from 3,175.0 GWh in 2019.[1,10]

Figure 2. **Annual Electricity Generation by Source in Tajikistan in 2019 (GWh)**



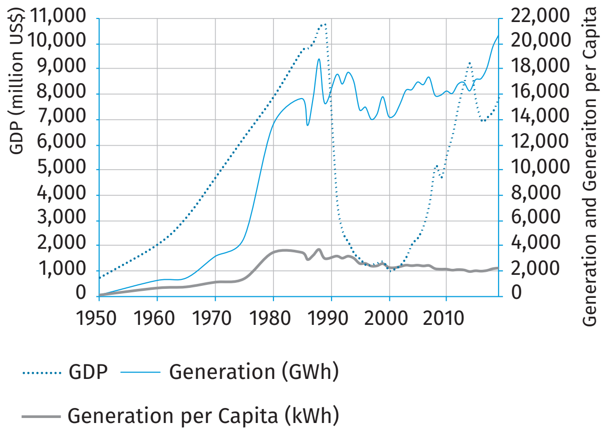
Source: Agency on Statistics[1]

Domestic electricity consumption in Tajikistan amounted to 15,350 GWh in 2019. Electricity consumption in areas serviced by Barki Tojik is dominated by households, industry and agriculture, while consumption in the GBAO is accounted for almost exclusively by household users. Access to electricity in Tajikistan was nearly 100 per cent as of 2019, including 98 per cent in the GBAO. At the same time, temporary caps on electricity use are a common occurrence, particularly in the winter when generation from hydropower declines due to reduced water availability. Per capita annual electricity consumption averages 788 kWh in the GBAO and 1,043 kWh in the rest of Tajikistan. However, accounting for the fact that the GBAO is almost completely deprived of industry, electric transport and mechanized irrigation, per capita consumption in households is nearly the same across all parts of the country.[1,10,11,12,13,14,15,16]

The transmission and distribution grid operated by Barki Tojik includes 489 kilometres of 500 kV power lines, 1,860 kilometres of 220 kV lines, 4,327 kilometres of 110 kV lines, 2,476 kilometres of 35 kV lines and 21,500 kilometres of 6-10-20 kV lines. The distribution system includes 3 500 kV substations, 28 220 kV substations, 174 110 kV substations and 223 35 kV substations. Pamir Energy operates a total of 4,300 kilometres of power lines with distribution substations.[10]

Hydropower has historically been and remains the mainstay of the electric power sector in Tajikistan, providing the bulk of installed electricity capacity and being responsible for almost all generation in the country. Generation from hydropower did not decrease even during the 1990–2000 period, which was marked by an acute crisis across most other economic sectors in the country. At the same time, the per capita annual generation of electricity decreased from 3,700 kWh in 1988 to 1,944 kWh in 2014 due to population growth, increasing again slightly in recent years (Figure 3).[1,8,10,17]

Figure 3. **Dynamics of Generation and Economic Development in Tajikistan in 1950–2010**



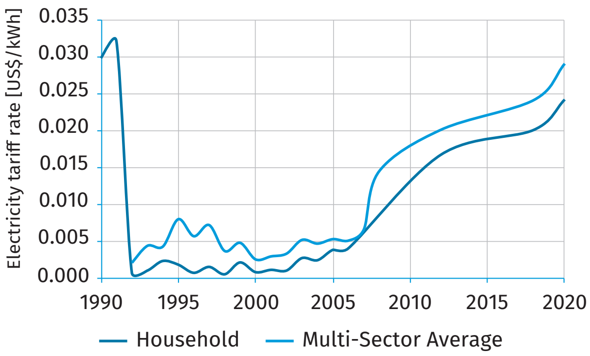
Source: Agency on Statistics,[1] MEWR,[8] Petrov & Akhmedov[17]

Further development of the hydropower sector is a key strategic priority for Tajikistan. The theoretical annual generation potential for hydropower in Tajikistan is estimated at 527 TWh, while the technically and economically feasible potential is estimated at 316 TWh.[10] In order to more fully realize this potential, the country is pursuing several development vectors, including the completion of the 3,600 MW Rogun hydropower plant (with an installed capacity of 400 MW as of 2021), as well as further development of SHP. An expansion of thermal energy capacities as well as of non-hydropower renewable energy sources (RES) is also planned.[9,10,18]

Electricity tariffs in Tajikistan are regulated by Barki Tojik, which uses the cost-based method of price formation. The average electricity tariff for households was 0.032 USD/kWh in 1990, dropping to 0.0042 USD/kWh in the economic crisis following the dissolution of the Soviet Union and has subsequently never recovered to previous levels, equalling only 0.024 USD/kWh in 2020 (Figure 4). Electricity tariffs for state-funded institutions in 2020 likewise equalled 0.024 USD/kWh, while for industry they equalled 0.057 USD/kWh, with the exception of the Tajikistan Aluminium Plant which pays 0.0074 USD/kWh in the summer and 0.0122 USD/kWh in the winter.[19,20,21,22,23]

The World Bank's recommendations issued along with a USD 134 million support package for Barki Tojik in 2020 stipulated raising the household tariff to at least 0.035 USD/kWh in order to ensure the financial stability of the company. The production cost of electricity from generating facilities in Tajikistan that have already paid back their investment costs is estimated at 0.0042 USD/kWh for hydropower and 0.0083 USD/kWh for other energy sources. However, studies have shown that newly built facilities can only pay back their construction cost under the current tariff regime at a construction cost of 1,000 USD/kW or less, suggesting tariffs must be raised if construction of more expensive facilities is to be possible.[17,20,23,24,25]

Figure 4. **Dynamics of Electricity Tariffs in Tajikistan in 1990–2020 (USD/kWh)**

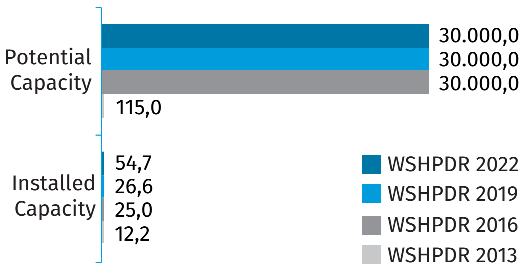


Source: Radio Ozodi,[20] MEWR,[21] Government of Tajikistan[22,23]

SMALL HYDROPOWER SECTOR OVERVIEW

The definition of SHP in Tajikistan encompasses hydropower plants with an installed capacity of up to 30 MW.[19] As of 2021, the total installed capacity of SHP up to 30 MW in the country was 142.1 MW, including 44.8 MW operated by Pamir Energy and 24.9 MW operated by IPPs, while the installed capacity of SHP of up to 10 MW was 54.7 MW.[9,10] Potential capacity for SHP of up to 10 MW in Tajikistan has been estimated at 30,000 MW, suggesting that only a small fraction of this potential has been developed.[26] Relative to the *World Small Hydropower Development Report (WSHPDR) 2019*, the installed capacity of SHP of up to 10 MW has more than doubled due to the installation of additional SHP plants and the availability of more accurate data, while the estimate of potential capacity has remained the same due to the absence of recent studies (Figure 5).[27]

Figure 5. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Tajikistan (MW)**



Source: MEWR,[9] Petrov,[10] Valamat-zade,[26] *WSHPDR 2019*,[27] *WSHPDR 2013*,[28] *WSHPDR 2016*[29]

Note: For SHP up to 10 MW.

The first SHP plant was constructed at the Khorog border station in 1913 and several additional SHP plants were built in the 1920s and 1930s. However, large-scale SHP development in the country only began after the Second World War, following the formulation and adoption in 1949–1950 of the Scheme of Use of Hydropower Resources of Small Watercourses for the Electrification of Agriculture in the Tajik Soviet Socialist Republic (SSR). The scheme substantiated the possibility of constructing 784 SHP plants on the territory of the Republic, of which 260 with a total capacity of 44.06 MW were initially scheduled for construction. By 1978, 69 SHP plants had been built with a total capacity of 32 MW. Subsequently, due to a policy reorientation in favour of large hydropower, the implementation of the scheme was suspended.[30,31,32,33]

Interest in SHP development in Tajikistan revived in the early 1990s. Schemes for the development of SHP in the Staro-Matchinskiy, Garmskiy and Jirgitalskiy districts of Tajikistan as well as in the GBAO were drafted in 1991 and 1995, outlining the construction of 112 additional SHP plants with a total installed capacity of nearly 429 MW. A nationwide Programme for the Construction of Small Power Plants for 2007–2020 was developed and adopted between 2006 and 2009. It included 189 SHP plants with a total capacity of 103.2 MW at a total cost of USD 123 million.[25,32,33,34] Under the framework established by these programmes, 155 run-of-river SHP plants were constructed in Tajikistan between 1995 and 2021 (Table 1).[24] A partial list of SHP plants constructed during these years is provided in Table 2.

Table 1. **Small Hydropower Construction in Tajikistan in 1995–2021**

Region	*Active SHP plants*		*Inactive SHP plants*		*Total*	
	Number	*Capacity (MW)*	*Number*	*Capacity (MW)*	*Number*	*Capacity (MW)*
GBAO	15	0.73	20	2.70	35	3.43
Districts of Republican Subordination	53	2.96	21	1.73	74	4.69
Khatlon Region	0	0	8	2.19	8	2.19
Sughd Region	37	1.00	1	0.88	38	1.88
Total	**105**	**4.69**	**50**	**7.50**	**155**	**12.18**

Source: Shupletsov et al.[24]

Table 2. **List of Selected Existing Small Hydropower Plants in Tajikistan**

Name	*Location*	*Capacity (MW)*	*Launch year*
Khatfat	Bartang Valley	0.450	2020
Tajikistan SHP	Murghab	1.500	2018
Tutak	Rasht	0.586	2013
Pitavkul-2	Jirgital	1.104	2012
Kukhistan-1	Gornaya Matcha	0.500	2012

Name	*Location*	*Capacity (MW)*	*Launch year*
Kukhistan	Gornaya Matcha	0.500	2012
Sangikar	Rasht	1.006	2011
Khorma	Baljuvan	0.180	2011
Shirkent	Tursunzade	0.576	2011
Panjrud	Penjikent	0.500	2011
Marzich	Ayni	4.299	2011
Dijik	Ayni	0.260	2011
Shashboloi	Nurobod	0.183	2010
Fatkhabad	Tajikabad	0.282	2010
Artuch	Penjikent	0.500	2008
Khazora-2	Varzob	0.250	2000
Khazora-1	Varzob	0.250	1999

Source: Barki Tojik[14]

The most significant prospects for SHP development in Tajikistan are currently found in the GBAO, as outlined in the Tajikgidroenergproekt study from 1995.[25] Several additional prospective SHP sites identified in central Tajikistan are listed in Table 3.

Table 3. **List of Selected Potential Small Hydropower Sites in Tajikistan**

Location	*Potential capacity (MW)*
Yormazor	2.3
Nazarmerghan	4.7
Sebzor	11.0
Dombachi	15.0
Khaftkul	18.0

Source: Petrov[10]

RENEWABLE ENERGY POLICY

Tajikistan has adopted a comprehensive package of legislation aimed at regulating, stimulating and creating a preferential environment for the construction and operation of SHP plants and other RES, including the following:

-
- The 1993 Resolution No. 1350 of the Presidium of the Supreme Council of the Republic of Tajikistan providing tax exemptions for SHP plants, non-conventional energy sources and small enterprises for coal mining and processing under construction, as well as outlining the order of construction and operation of RES facilities;
- The 1993 Resolution No. 139 of the Council of Ministers of the Republic of Tajikistan on measures to stimulate the development of small-scale power plants and to increase coal production in the Republic of Tajikistan, authorizing the construction of SHP plants at all operating non-powered hydraulic structures and reservoirs irrespective of their departmental affiliation.[10,35]

These measures have subsequently been superseded by more recent legislation, including:

- The 2007 Law on Investments, which established a system of incentives for foreign investors to participate in the construction of SHP plants;
- The 2015 Law on the Use of RES, which provides a number of benefits and preferences that significantly increased the economic efficiency of SHP plants;
- The 2015 Decree of the Government of the Republic of Tajikistan on the Programme of Development of RES and Construction of SHP plants for 2016–2020.[19,36,37]

The adopted legislative framework stipulates the following specific benefits for SHP plants and other RES facilities:

- Recognition of the use of RES as an environmentally friendly and/or energy saving activity;
- Connection of RES producers to power grids on a preferential basis;
- Obligation of power grid operators to purchase all power generated by RES facilities;
- Exemption from a tax on profits for three years following the start of commercial operation;
- Establishment of accelerated depreciation for RES facilities;
- RES tariff subsidies taking into account the costs of energy production and supporting their development for sale to grid operators.[10,19,35,36,37]

COST OF SMALL HYDROPOWER DEVELOPMENT

The majority of SHP development in Tajikistan takes place with the support of foreign grants, the financial resources of Barki Tojik as well as the developers' private funds. The cost of construction can fluctuate anywhere from 1,420 USD/kW as in the case of a 175 kW SHP plant constructed in Basid Village of the Bartang Valley in 2016 with the support of donations from the Government of Switzerland and private donors to the 10,000 USD/kW required for the reconstruction of the 1.5 MW Ok-su SHP plant in Murghab, completed in 2018. The economic efficiency and payback period of the projects are generally not considered, with the exception of projects taking place in the GBAO, where Pamir Energy takes investment costs into account in electricity tariffs.[10,38,39]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

The hydropower resources of Tajikistan are significantly larger than the country's current and projected needs for electricity. Given the low level of utilization of the country's technically and economically feasible hydropower potential (approximately 7 per cent), even the expected reduction in glacier volume and runoff is unlikely to have a significant negative impact on the functioning and development of hydropower in Tajikistan. However, global warming may affect large hydropower used for both electricity generation and irrigation purposes, requiring the construction of additional regulating reservoirs.[10]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The primary barriers to SHP development in Tajikistan include the following:

- Low electricity tariffs that are sufficient to ensure the continuous operation of existing hydropower infrastructure but insufficient to recoup the costs of new construction;
- The established practice of micro-hydropower construction, which are less cost-effective than SHP plants of 500 kW and above;
- Insufficient technological, economic and hydrological data on the feasibility of SHP construction on specific sites;
- The fragmentary and uncoordinated nature of the SHP planning, financing, construction, operation and regulation processes, distributed among a variety of private, public and international stakeholders.

The aforementioned issues can be overcome by the adoption of a systemic approach to the SHP sector that would ensure sufficient data collection on existing and prospective SHP sites, proper planning of the development of supporting infrastructure as well as sectors tangential to SHP, including domestic manufacturing of equipment and the training of technical personnel. Future SHP development can take advantage of several enabling factors, including:

- Massive untapped SHP potential;
- The advantage SHP enjoys over large hydropower with regard to access to sufficient financing.

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Turkmenistan

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KEY FACTS

Population	5,942,089 (2019)[1]
Area	491,210 km^2 [2]
Topography	More than 80 per cent of Turkmenistan is occupied by the Kara-Kum Desert, which is bounded in the east by the Amu Darya River and in the west by the Caspian Sea. Major mountain ranges include the Kopet Dagh Range on the southern border with Iran and the Köýtendag Range in the east, which includes Mount Ayrybaba (3,139 metres above sea level), the highest point in the country.[3]
Climate	Turkmenistan has a very dry, continental climate, experiencing extremely hot summers and moderate winters with frequent rain and occasional, but rare, snowfall. Daytime temperatures between May and September can exceed 40 °C, while temperatures in January range between −6 °C and 4 °C.[4]
Climate Change	Turkmenistan is a country at particular risk from climate change, especially in the areas of agriculture, water resources, public health and the integrity of ecosystems. Climate change in Turkmenistan is proceeding at a rapid pace. Between 1993 and 2003, the mean annual temperature increased by 0.18–0.2 °C. By 2100, further temperature increases are projected to range anywhere from 2–3 °C to 6–7 °C. Other shifts in the climate of Turkmenistan have included an increase in the difference of maximum and minimum temperatures as well as an increase in rainfall variability. This has led to prevailing drought-type conditions, on the one hand, and more extreme rainfall events, on the other, with flooding and mudflows becoming more common.[5]
Rain Pattern	Average yearly rainfall in Turkmenistan ranges between 80 and 200 mm. However, the intra-annual as well as the inter-annual distribution of precipitation is highly variable. Most annual precipitation occurs over the course of a few days (typically, two–six); the maximum recorded single-day rainfall was 124 mm. The total amount of annual precipitation in the Kara-Kum Desert can vary from 24 mm to 564 mm.[6]
Hydrology	Major rivers in the country include the Amu Darya (2,540 km), Heray Rud (1,124 km), Morghab (852 km) and Atrek (660 km). The Amu Darya is the longest river in Central Asia and provides 88 per cent of the water resources in the country. Artificial bodies of water include the Kara Kum Canal, one of the largest irrigation and water supply canals in the world, which brings water from the Amu Darya, Morghab and Heray Rud Rivers to the south. The canal enables the irrigation of more than 1 million hectares of land and has a total irrigation potential of 2,353,000 hectares. Meanwhile, the Altyn Asyr reservoir, commissioned in 2009, is supplied by irrigation runoff from territories in the south via a network of collection and conveyance canals and is the most important water resources facility in the north-western desert region.[7,8,9]

ELECTRICITY SECTOR OVERVIEW

The electricity sector of Turkmenistan is dominated by thermal power plants running on natural gas, in addition to a single hydropower plant. In 2017, there were reported to be twelve power plants in operation equipped with a total of 14 steam turbines, 32 gas turbines and three hydropower turbines, with a total installed capacity of 5,178.4 MW.[10,11,12] There is some ambiguity on current total installed capacity, which has been increasing due to upgrades to existing thermal plants. The most recent estimates suggest a total installed capacity of 6,511.2 MW as of January 2021, with the number of power plants remaining the same as in 2017.[13,14] The 2021 installed capacity by energy source is displayed in Figure 1; while more recent data on the individual installed capacities of the power plants currently operational in Turkmenistan are difficult to acquire, available 2017 figures are displayed in Table 1. Table 1 does not account for the upgrades conducted on the Mary steam and gas power plant in 2018, which raised the plant's installed capacity to 3,400 MW.[15]

Figure 1. **Installed Electricity Capacity by Source in Turkmenistan in 2021 (MW)**

Source: Turkmenistan Today,[13] Central Asia News[14]

Table 1. **Major Power Plants in Operation in Turkmenistan in 2017**

Plant	*Type*	*Installed capacity (MW)*
Mary	Steam and gas	1,831.7
Ahal	Gas	648.1
Derweze	Gas	504.4
Turkmenbashy	Steam	420.0
Balkanabat	Gas	380.2
Abadan	Steam and gas	321.0
Awaza	Gas	254.2
Ashgabat	Gas	254.2
Dashoguz	Gas	254.2
Seydi	Steam	160.0
Lebap	Gas	149.2
Hindigush	Hydropower	1.2
	Total	**5,178.4**

Source: Ministry of Energy,[10] Turkmenportal.com,[11] IEEJ,[12] Ministry of Energy[16]

In 2016, annual electricity generation exceeded 24 TWh and electricity exports equalled 3.2 TWh.[17] By comparison, in the first three quarters of 2020, generation equalled 19.3 TWh (a 16.3 per cent increase over the analogous period of 2019), while 3.6 TWh were exported.[13] Electricity consumption for the most recently available year (2016) equalled 16.4 TWh, dominated by the commercial and public services sector and the transport sector.[17,18]

Electricity tariffs in Turkmenistan are set by the state-owned company Turkmenenergo, which owns and operates the grid, manages the electricity market and distributes electricity to the end consumers.[19] Electricity tariffs valid from 1 November 2017 are shown in Table 2.

Table 2. **Electricity Tariffs in Turkmenistan**

Consumer type	*Rates per 100 kwh*
Legal entities financed from the state budget and their equivalents	TMT 3.31 (USD 0.95)
State-owned self-supporting legal entities, non-state-owned legal entities engaged in business, individual entrepreneurs	TMT 6.28 (USD 1.80)
Foreign citizens, stateless persons and refugees	TMT 2.17 (USD 0.62)
Foreign legal entities	USD 3.58
Diplomatic missions, international and intergovernmental organizations	TMT 3.31 (USD 0.95)
Citizens of Turkmenistan who do not engage in entrepreneurial activity	TMT 2.50 (USD 0.71)*

*for consumption above the free-of-charge limit of 35 kWh

Source: News Central Asia[20]

The development plans of Turkmenistan for the years 2019–2025 include the construction of seven additional large-scale energy facilities.[14] By 2035, annual generation is expected to reach 35.5 TWh.[21] Ongoing projects include a gas power plant in the Lebap Region of 432 MW capacity being installed by a joint Japanese-Turkish venture and two gas power plants of 70 MW capacity at the Turkmenbashi Complex of Oil Refineries, whose installation began in September 2020.[22,23] A 10 MW combined solar-wind power plant is planned near the Altyn Asyr reservoir region by 2025.[24] There are also plans to construct high-voltage lines along the Mary–Serakhs–Mashhad route in order to increase electricity exports to Iran. Of additional importance is the planned Turkmenistan–Afghanistan–Pakistan energy bridge, with the Mary-Herat section under construction as of 2020.[14] This 500 kV transmission line will provide upwards of 4 GW of electricity from Turkmenistan, providing for the long-term energy needs of the other two countries and facilitating power trade and exchange among all three participating partners.[17]

SMALL HYDROPOWER SECTOR OVERVIEW

There has been little development of hydropower in Turkmenistan in the last century. There is no nationally-adopted definition of small hydropower (SHP), so the 10 MW definition is adopted for the purposes of the current chapter. The country's only SHP plant, the Hindigush hydropower plant on the Murgab River, was built in 1913 with a capacity of 1.2 MW and remains operational to this day. The country's SHP potential is estimated at 1,300 MW, of which less than 0.1 per cent has been developed. Most of the hydropower potential is located in the Murgab and Amu-Daria River basins, on the Tejen River and the Kara Kum Canal. With Turkmenistan having the world's fourth-largest reserves of natural gas, the cheap cost of gas has discouraged investment in renewable energy.[17,19] Since the *World Small Hydropower Development Report (WSHPDR) 2019*, the SHP sector of the country has not seen any changes, neither in installed nor potential capacity (Figure 2).

Figure 2. **Small Hydropower Capacities in the WSHPDR 2013/2016/2019/2022 in Turkmenistan (MW)**

Sources: *WSHPDR 2019*,[17] UNDP,[19] *WSHPDR 2013*,[25] *WSHPDR 2016*[26]

Previous editions of the *WSHPDR* have reported on plans to expand the hydropower sector in Turkmenistan. These have included the 2011 plans for refurbishment of the Kaushut-Bent and Kolkhoz-Bent SHP plants by the European Bank for Reconstruction and Development, as well as the construction of additional plants along the Kara Kum Canal and the Murgab and Tenjen Rivers.[17,25,26] The proposed projects are listed in Table 3 and Table 4; as of 2021, no progress has taken place with respect to any of these proposals.

Table 3. **Proposed Programme for Small Hydropower Development in Turkmenistan**

Type of construction	*Quantity*	*Potential Capacity (MW)*	*Note*	*Region*
Construction and rehabilitation of existing hydropower plants	3	4.7	Mostly former rural hydropower plants of capacity between 0.8 and 2.7 MW	Lolontan region on Murgab River
Addition of hydropower plants to water management projects	6	52.3	Hydropower plants of capacity between 2.6 and 15 MW	South Turkmenistan, Kara Kum Canal, Murgab and Tenjen Rivers
Total	**9**	**57.0**		

Source: *WSHPDR 2013*[25]

Table 4. **Priority Hydropower Projects in Turkmenistan**

Project	*Potential installed capacity (MW)*	*Location*
Hauznan reservoir HPP	11.7	Kara Kum Canal, Mary
Kopetdag reservoir HPP	15.0	Kara Kum Canal, Ashkhabad
Saryyazin reservoir HPP	12.0	Murgab River, Mary
Tashkeprin HPP	7.0	Murgab River, Mary

Source: *WSHPDR 2013*[25]

While no SHP development is currently taking place in Turkmenistan, the ongoing extension of the return water conveyance network into the Altyn Asyr reservoir could present an opportunity for SHP in the future. The purpose of this project is to redirect irrigation runoff from all irrigated territories in Turkmenistan into the reservoir, thereby accomplishing the following:

- Irrigation of agricultural and marginal pastureland in the north-western part of the country;
- Reversal of soil salinization of irrigated areas by lowering the water table;
- Prevention of evaporative and infiltration losses of irrigation runoff;
- Prevention of the contamination of natural streams, such as the Amu Darya, with irrigation runoff;
- Provision of additional economic opportunities for the region in the form of aquaculture and ecotourism.

The total length of the collection and conveyance channels in the network will be 2,654 km, with the main channel having a length of 720 km and a discharge of 240 m^3/s at the mouth.[9,27] As reduction of evaporative losses is one of the primary goals of the Altyn Asyr project and the associated channel network, installation of solar photovoltaic (PV) panels over the surface of the channels to provide shade while producing energy, as has been proposed in similar environments, presents an additional opportunity. The generated energy could be used in combination with small reservoirs and hydropower turbines to provide energy to pumping stations for irrigation or energy storage, or feed directly into the grid.[17,28]

RENEWABLE ENERGY POLICY

Due to the abundant natural gas reserves in Turkmenistan, development of renewable energy policies and capacities has been slow. The country is estimated to have significant renewable energy potential (Table 5), but some earlier projections estimate a contribution of less than 1 per cent from renewable energy to the overall energy mix of Turkmenistan by 2030.[29]

Table 5. **Estimated Potential of Renewable Energy Resources in Turkmenistan**

Resource	*Technical potential (MW)*
Solar power	655,000
Wind power	10,000
SHP (< 10 MW)	1,300
Total	**666,300**

Source: UNDP[19]

Renewable energy policy in Turkmenistan has been evolving over the last decade. The Law on Renewable Sources of Energy has been in development since 2011, but has not been passed into law as of 2021.[30] In 2014, Turkmenistan established the Solar Energy Institute within the Academy of Sciences of Turkmenistan and in 2018 adopted a plan for the development of cooperation with the International Renewable Energy Agency (IRENA) by 2023.[31,32] Also in 2018, Turkmenistan adopted the State Programme on Energy Efficiency for 2018–2024, which includes stipulations on reducing energy losses and controlling pollution from traditional energy sources.[33] Developments in renewable energy policy in 2020 included negotiations with Turkey and Azerbaijan on trilateral cooperation in the area of renewable energy as well as initial studies on implementing a large-scale solar energy project near the Altyn Asyr reservoir.[34,35]

A key development was the establishment of the Interdepartmental Working Group to draft a National Strategy of Turkmenistan for the Development of Renewable Energy until 2030 in June 2020 and approval of the National Strategy in December of the same year. The strategy puts a particular emphasis on the reduction of greenhouse gas emissions and the development of solar power, taking advantage of the country's considerable solar power potential. Additional plans include the establishment of a National Agency of Renewable Energy.[36]

EFFECTS OF CLIMATE CRISIS ON SMALL HYDROPOWER DEVELOPMENT

Climate change in Turkmenistan is expected to increase the incidence of extreme weather events, including both droughts and flooding.[5] This will cause discharge in available water courses to become less predictable and undermine the reliability of potential SHP projects, especially those without a reservoir. An additional hazard for SHP is the observed and projected increase in mudflows during extreme rain events, which could cause significant damage to facilities.[5]

Overall, the hydrological outlook for Turkmenistan projects an expected decrease in precipitation of 8–17 per cent by 2100. The total discharge of the Amu Darya, the country's largest river, is expected to decrease by 5–10 per cent by 2050, while that of the smaller Murgab, Tenjen and Atrek Rivers is expected to decrease by 5–8 per cent by 2030. Local rivers could experience discharge decreasing by as much as 30 per cent during the vegetation period.[5,9]

While these changes would not significantly affect the overall near-term prospects of SHP in the country, given the large gap between the installed capacity and the undeveloped potential, they could outsize local impacts if certain streams were to dry up or change course as a result of shifting precipitation patterns.

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The main barriers to the development of SHP in Turkmenistan are:

- The low prices for energy produced with traditional fossil fuels (natural gas);
- The continuing lack of a comprehensive regulatory framework and policies for the promotion of renewable energy.[19]

However, in recent years, several factors enabling the development of SHP in Turkmenistan have also emerged, including:

- The increased international emphasis on renewable energy as a whole and the active participation of Turkmenistan in multilateral and bilateral agreements with neighbouring countries as well as international agencies on the development of renewable energy;
- Development of national policy instruments dedicated to promoting renewable energy, of which the most important are the draft Law on Renewable Sources of Energy and the National Strategy of Turkmenistan for the Development of Renewable Energy until 2030;
- The ongoing construction of the return waters conveyance network and the Altyn Asyr project, which can be expected to provide both additional potential capacity and additional demand for SHP in previously remote desert regions of the country once complete.

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Uzbekistan

International Center on Small Hydropower (ICSHP)

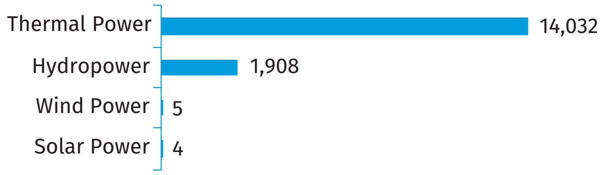
KEY FACTS

Population	35,271,300 (2022)[1]
Area	447,400 km^2 [2]
Topography	Uzbekistan can be divided into three physiographical zones: the arid and semi-arid regions, located mainly in the central and western parts of the country and covering 60 per cent of the country's territory; valleys along the Amu Darya and Syr Darya Rivers; and the mountainous region in the east consisting of the Tien Shan and Gissaro-Alay Mountain Ranges.[3] The highest point in the country is Khazret Sultan, at 4,643 metres, while the lowest point is Sariqarnish Kuli, at 12 metres below sea level.[4]
Climate	The climate of Uzbekistan is continental, with hot summers and cool winters. Summer temperatures range from 42–47 °C on the plains to 25–30 °C in the mountains. In winter, temperatures are between -11 °C in the north and 2–3 °C in the south.[3]
Climate Change	Observed effects of climate change in Uzbekistan have included an increase in minimum and maximum air temperatures of 2.0 °C and 1.6 °C, respectively, between 1950 and 2013. Average annual temperatures rose by an average of 0.27 °C per decade over the same period. Climate change projections across several scenarios predict an increase in average annual temperatures of 1.9–5.7 °C by 2071–2090, relative to the 1980–1999 baseline period.[5]
Rain pattern	Most of the country is quite arid, with rainfall occurring mainly between October and April. Average annual rainfall is 264 mm and ranges from 97 mm in the north-west to 425 mm in the mountains in the centre and the south.[3]
Hydrology	Two river basins are found in Uzbekistan, which form the Aral Sea basin: the Amu Darya basin, which covers nearly 82 per cent of the country, and the Syr Darya basin covering approximately 14 per cent of the country. The total average water inflow of the two basins in Uzbekistan is approximately 102.2 km^3.[3] There are 656 rivers in the country, and thousands of small streams that disappear in the desert. Many rivers are redirected for irrigation via extensive canal systems, such as the Amu-Bukhara canal. There are also artificial lakes and reservoirs, many of which are fed by the irrigation runoff. [5,6]

ELECTRICITY SECTOR OVERVIEW

The total installed capacity of Uzbekistan in 2019 was approximately 15,949 MW. The largest share of this total, 14,032 MW (88 per cent) was provided by thermal power, while 1,908 MW (12 per cent) was provided by hydropower, and wind power and solar power contributed a combined 9 MW (less than 1 per cent) (Figure 1).[7]

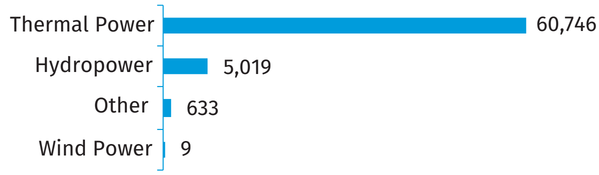
Figure 1. **Installed Electricity Capacity by Source in Uzbekistan in 2019 (MW)**



Source: EES EAEC[7]

Total gross electricity generation in Uzbekistan reached approximately 66,407 GWh in 2020, with thermal power providing 60,746 GWh (91 per cent) of the total, hydropower providing 5,019 GWh (8 per cent), other sources providing 633 GWh (1 per cent) and wind power providing 9 GWh (less than 1 per cent) (Figure 2). Imports of electricity amounted to 11,266 GWh, while exports were 8,627 GWh, with imports exceeding exports for the third year in a row since 2018, reversing the trend of exports exceeding imports observed in 2010–2018.[8]

Figure 2. **Annual Electricity Generation by Source in Uzbekistan in 2020 (GWh)**



Source: CIS Electric Power Council[8]

Access to electricity in Uzbekistan is 100 per cent.[9] Electricity consumption by end users in 2019 amounted to 54,175 GWh, including 17,382 GWh by the industrial sector, 15,058 GWh by agriculture, forestry and fisheries, 13,479 GWh by households, 4,971 GWh by the commercial sector, 2,115 GWh by transport and 1,170 GWh by other users. Transmission losses in 2019 accounted for 3,858 GWh, or approximately 6 per cent of gross generation.[7]

All hydropower plants of Uzbekistan are owned by Uzbekgidroenergo JSC, established in 2017.[10,11] Uzbekgidroenergo JSC was appointed by the Government as the co-coordinating body responsible for the implementation of the Programme for Hydropower Development in Uzbekistan in 2017–2021.[12]

Most of the power generation, transmission and distribution assets in Uzbekistan used to be owned and operated by Uzbekenergo JSC, which was reorganized in 2018–2019 with a view of improving efficiency of the electricity sector in the country following the World Bank recommendations. Uzbekenergo JSC was split into three independent companies: Thermal Power Plants JSC, Uzbekistan National Electric Power Networks JSC and Regional Electric Power Networks JSC.[11] The hydropower assets of Uzbekenergo JSC were transferred to Uzbekgidroenergo JSC in 2017. All these companies are state-owned, although there are plans for the privatization of the energy sector in the country.[13,14]

Uzbekistan used to be part of the Central Asia Integrated Power System (CAIPS), which was established for mutual power trade among the Central-Asian republics of the Soviet Union. In 2009 Uzbekistan halted its participation in CAIPS, although the interconnections between Uzbekistan and other Central Asian countries remained functional.[15]

All consumers in Uzbekistan are connected to the centralized power supply system, except for some remote rural areas that rely mostly on off-grid power generation.[16] The total length of power transmission and distribution lines of all voltages was nearly 264,088 kilometres in 2019, with much of the network's lines being 30 years old on average.[8,17] Aging infrastructure and insufficient investments have increasingly resulted in reliability problems with the power supply, with periodic failures of old transmission and distribution infrastructure and transmission capacity bottlenecks leading to disruptions.[18]

Recognizing these challenges, the Government of Uzbekistan places high priority on energy sector reforms, with the aim of attracting foreign investment funds to carry out reconstruction, modernization and further development of power generating facilities and the power grid.[19] A roadmap to modernize the electricity sector over 2018–2020 was approved in 2018, providing for the implementation of seven investment projects for the modernization of existing and commissioning of new generating capacities of 1,984 MW and with a project cost of USD 2.6 billion.[20] The long-term plans of the roadmap included significantly increasing the installed capacities of all existing energy sources as well as building the first nuclear power plant.[21]

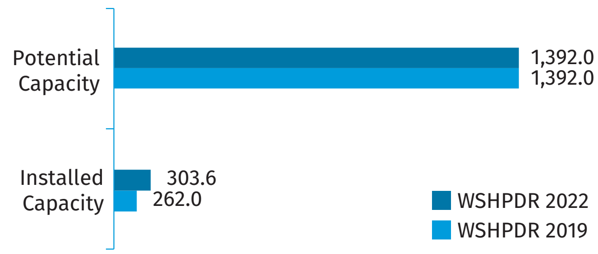
In 2019, the Government introduced a long-term tariff policy for the electric power industry up to 2030, which provides for the financial stability and investment potential of the industry.[22] As of August 2019, electricity tariffs for residential users were 295 UZS/kWh (0.027 USD/kWh) and 450 UZS/kWh (0.041 USD/kWh) for other users.[23]

SMALL HYDROPOWER SECTOR OVERVIEW

The definition of small hydropower (SHP) in Uzbekistan is up to 30 MW as stated in the Law of the Republic of Uzbekistan on the Use of Renewable Energy Sources and the Programme of actions for further development of renewable energy and increase of energy efficiency in 2017–2020.[24,25]

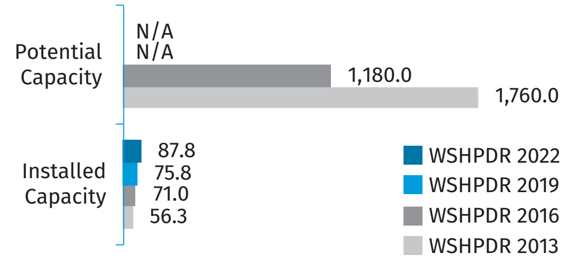
There were over 250 SHP plants up to 30 MW in Uzbekistan at the beginning of the 1960s, operating without a connection to the national grid, but most of these are no longer in use.[26] In 2018, there were 27 SHP plants with installed capacities of up to 30 MW and a total installed capacity of approximately 278 MW. This included 15 SHP plants with installed capacities of up to 10 MW, whose combined installed capacity was 75.8 MW.[2,27] In 2019, several additional SHP plants were commissioned in Uzbekistan, including the 12 MW Tuyabogiz SHP plant in Tashkent Province and two 6 MW SHP plants on the Grand Fergana Canal, while upgrades to the Oktepa SHP plant completed in 2020 increased the installed capacity of the plant from 15 MW to 16.6 MW.[28,29,30] Consequently, the total installed capacity of SHP in Uzbekistan as of 2020 is estimated at 303.6 MW for SHP up to 30 MW and at 87.8 MW for SHP up to 10 MW, increasing by approximately 16 per cent for both SHP categories relative to the *World Small Hydropower Development Report (WSHPDR) 2019*. The technical potential of SHP up to 30 MW has been estimated at approximately 1,392 MW, indicating that nearly 22 per cent has been developed (Figure 3).[27,31] No data on the potential of SHP up to 10 MW are currently available (Figure 4).

Figure 3. **Small Hydropower Capacities up to 30 MW in the WSHPDR 2019/2022 in Uzbekistan (MW)**



Source: Nurmatov,[2] CER & UNDP,[27] The Tashkent Times,[28,29] Uzbekhydroenergo,[30] *WSHPDR 2019*[31]

Figure 4. **Small Hydropower Capacities up to 10 MW in the WSHPDR 2013/2016/2019/2022 in Uzbekistan (MW)**



Source: CER & UNDP,[27] The Tashkent Times,[29] *WSHPDR 2019*,[31] *WSHPDR 2013*,[32] *WSHPDR 2016*[33]

The Government of Uzbekistan is gradually increasing investments in the SHP sector by implementing programmes for building new SHP plants and upgrading the existing ones. For example, the Programme for Hydropower Development in 2017–2021, subsequently amended to extend the planning horizon to 2030, included plans for the construction of 35 SHP plants up to 30 MW with a total installed capacity of 349 MW, as well as plans for increasing the installed capacity of 23 existing SHP plants up to 30 MW to a total capacity of 251.4 MW. These projects were provided with investments from international lenders under credit guarantees by the Government of Uzbekistan.[31,34]

Table 1. **Small Hydropower Projects under Construction in Uzbekistan as of 2021**

Name	*Location*	*Watercourse*	*Capacity (MW)*	*Plant type*	*Developer*
Tamshush	Shahrisabz district, Kashkadarya region	Aksu River	10.0	Run-of-river	Uzbekhydroenergo JSC
Kamolot	Chirchik, Tashkent region	Chirchik River	8.6	N/A	Uzbekhydroenergo JSC
Chappasu	Shahrisabz district, Kashkadarya region	Aksu River	8.0	Run-of-river	Uzbekhydroenergo JSC
Rabat	Shahrisabz district, Kashkadarya region	Aksu River	6.0	Run-of-river	Uzbekhydroenergo JSC

Source: Uzbekenergo,[35] Renewable Energy World,[36] Mutin[37]

In 2021, a new programme of hydropower development was announced, targeting the accelerated development of micro- and small hydropower. Planned legislative changes to be enacted as part of the programme include redefining SHP as hydropower plants up to 5 MW, with plants between 5 MW and 30 MW classified as medium hydropower.[38]

Table 2. **Potential Small Hydropower Sites in Uzbekistan**

Name	*Location*	*Watercourse*	*Planned capacity (MW)*	*Planned launch year*
Tashbulak	Shahrisabz district	Tankhizydarya River	3.8	2021-2023
Shurdzhin	Shahrisabz district	Tankhizydarya River	3.8	2023-2025
Suvlisay	Yakkabag district	Kyzyldarya River	7.7	2022-2024
Khitai	Shahrisabz district	Tankhizydarya River	3.0	2026-2028
Samak	Yakkabag district	Kyzyldarya River	6.5	2026-2028
Karatut	Shahrisabz district	Tankhizydarya River	3.0	2028-2030
Kineguzar	Denau district	Sangardakdarya River	22.0	2028-2030

Source: President of the Republic of Uzbekistan[34]

RENEWABLE ENERGY POLICY

Uzbekistan has a legal framework targeting the rational use of natural resources and developed in line with international standards.[39] In particular, in 2019 the Parliament of the Republic of Uzbekistan approved Law of the Republic of Uzbekistan on the Use of Renewable Energy Sources.[24] This law introduced some financial and tax privileges for renewable energy projects. Several state programmes and national action plans are also being implemented with regard to renewable energy, including the Presidential Decree No. PP-3012 On the Programme of Actions for the Further Development of Renewable Energy and Energy Efficiency in Sectors of the Economy and Social Services in 2017–2021.[25,40] Uzbekistan has ratified major United Nations conventions and other international instruments in the field of environmental protection and sustainable development.

A selective review of the current use of alternative energy sources in Uzbekistan carried out in April 2018 by the Uzbekistan State Committee for Statistics found that approximately 3.9 per cent of enterprises in the country had installed at least one type of renewable energy source on the premises, with biogas installations being most popular (2.7 per cent). This indicated a modest increase in the use of alternative energy sources relative to the 3.7 per cent of enterprises using renewable energy in 2017.[39]

BARRIERS AND ENABLERS FOR SMALL HYDROPOWER DEVELOPMENT

The key challenges for the development of SHP in Uzbekistan are:

- High availability of thermal power sources such as natural gas and coal;

- Aging energy infrastructure;
- Lack of financing and investment in the renewable energy sector;
- Low electricity prices;
- Lack of clear support mechanisms for SHP development;
- Lack of feasibility studies and available data on SHP potential.

Enabling factors for the development of SHP include the following:

- Large number of formerly operating SHP plants that may potentially be refurbished or rebuilt;
- Significant untapped SHP potential of natural watercourses and canals;
- New policies supporting the development of SHP and other renewable energy sources.

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