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Current status and future prospects of hydropower plants in Central Asia

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ABSTRACT: Hydroelectric energy, also called hydroelectric power or hydroelectricity, is a form of energy that harnesses the power of water in motion such as water flowing over a waterfall to generate electricity. Most hydroelectric power plants have a reservoir of water, a gate or valve to control how much water flows out of the reservoir, and an outlet or place where the water ends up after flowing downward. In this article, it will discuss the achievements and shortcomings of the Central Asian countries, such as Uzbekistan, Kazakhstan, Kyrgyzstan and Tajikistan in the last decades. In addition, the report debates the fact that Central Asia is a region with hydropower potential and many decisions and reforms to be implemented in the near future. Some of the countries of Central Asia are moving in this direction. Faced with a prospective shortage of gas within the domestic energy system, the Uzbek authorities see a lot of potential in the modernization of existing hydropower plants and the construction of new, smaller hydropower plants.

KEY WORDS: Hydroelectric energy, hydroelectric power, hydroelectricity, HPP, energy system, hydro project, hydroelectric facilities, irrigation, aggregate.

I. INTRODUCTION

Hydroelectricity, or hydroelectric power, is electricity produced from hydropower. In 2020 hydropower generated one sixth of the world's electricity, almost 4500 TWh, which was more than all other renewables combined and also more than nuclear power [2].

There are some kind of hydroelectric power stations:

- Large-scale hydroelectric power stations are more commonly seen as the largest power producing facilities in the world, with some hydroelectric facilities capable of generating more than double the installed capacities of the current largest nuclear power stations. Although no official definition exists for the capacity range of large hydroelectric power stations, facilities from over a few hundred megawatts are generally considered large hydroelectric facilities [2].
- Small hydro is the development of hydroelectric power on a scale serving a small community or industrial plant. The definition of a small hydro project varies but a generating capacity of up to 10 megawatts (MW) is generally accepted as the upper limit of what can be termed small hydro [2].
- Micro hydro is a term used for hydroelectric power installations that typically produce up to 100 kW of power. These installations can provide power to an isolated home or small community, or are sometimes connected to electric power networks [2].
- Pico hydro is a term used for hydroelectric power generation of under 5 kW. It is useful in small, remote communities that require only a small amount of electricity [2].

It is also undergoing a lot of construction and modernization in the field of hydropower in Central Asia. The article discusses the achievements and shortcomings of the Central Asian countries (Uzbekistan, Kazakhstan, Kyrgyzstan and

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Tajikistan) in the last decades. Besides, the report converses the fact that Central Asia is a region with hydropower potential and many decisions and reforms to be implemented in the near future.

The two countries in the region (Turkmenistan and Afghanistan) have not considered their hydropower potential.

Compared to its neighbors in the Central Asian region Tajikistan's hydroelectric power production looks biggest [3]. In the ranking of countries in the Central Asia, Tajikistan is the first, and it's share is 41 % in terms of total HPP capacity in 2015 (Figure 1).

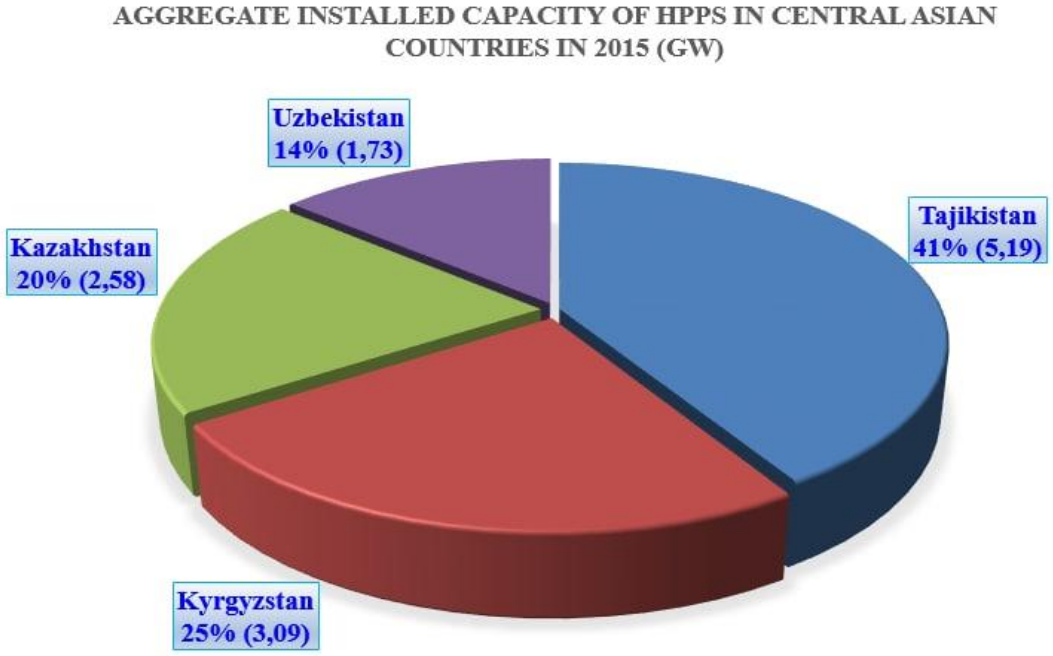

Figure 1. Aggregate installed capacity of HPPs in Central Asian countries in 2015 (the data are given in GW)

II. HYDROELECTRIC POWER PLANT (HPP) IN KAZAKHSTAN.

The great feature energy system of Kazakhstan is its thermal power-generating sector, which is coal and gas-dependent. This sector provides up to 89% of the country's electrical power production. The hydroelectric power plant (HPP) sector in turn accounts for about 11% of electricity generation. No more than 0.12% of overall production is provided for by wind and solar power [4].

However, the aggregate capacity of Kazakhstan's hydroelectric power facilities according to the operator of the national unified power system JSC "KEGOS" amounted to 2584 MW as of 2014. Available capacity drops to 1461 MW in winter times. Kazakhstan is existing hydroelectric power plant stations the Leninogorsk cascade (13.8 MW; referring here and subsequently to 'installed capacity') launched in 1928 has the longest history. The most modern of the major stations meanwhile is the Moynak HPP, launched in 2011, which reached its current full capacity of 300 MW a year later. In 2013 a series of smaller hydropower stations in Almaty and Zhambyl regions were put into production. The average age of Kazakhstan's hydropower infrastructure is 36.5 years [5].

Kazakhstan's hydroelectric power plant facilities are concentrated in 4 regions: The East Kazakhstan Region (EKR), Almaty, Zhambyl and South Kazakhstan (SKR) regions. In EKR there is the Shulbinskaya HPP (702 MW) and the Ust-Kamenogorsk HPP (331 MW) in addition to the aforementioned Leninogorsky HPP [4,5].

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The Almaty region has 2 power stations – Moynak HPP (300 MW) and the Kapchagai HPP (364 MW) as well as the Almaty Cascade HPP (47 MW) and a series of mini-hydropower plants: Aksu - 1 HPP (1.9 MW), Issyk HPP – 2 and 3 (6.1 MW), Karatal HPP 2 , 3 , 4 (11.9 MW), Sarkand HPP (0.5 MW), Antonovskaya HPP – 3 (1.6 MW), HPP Uspenovskaya-4 (2.5 MW) and Intalinskaya HPP-5 (0.6 MW). In Zhambyl region there are the following mini-hydro facilities: Merken HPP- 1, 2 , 3 (3.6 MW), Karakystakskaya HPP (2.1 MW), Tasotkelskaya HPP (9.2 MW). The only HPP in SKR is Shardara. It has an installed capacity of 100 MW that is expected to grow to 126 MW pending completion of an on-going upgrade [5,6].

Since all of Kazakhstan's hydropower stations have a relatively small apacity, their task is to adjust to changing load schedules, performing the classic function of flexible generation while helping to "close out" peaks in consumption [8]. Thus, there is a role for hydropower plants as important elements of a national power system, but their future development remains uncertain. Despite the fact that in the past 25-30 years, the aggregate capacity of Kazakhstan's HPP sector has grown, the overall consumption of HPP-sourced energy only returned to the levels of the late 1980 years by the middle 2010 years (Figure 2).

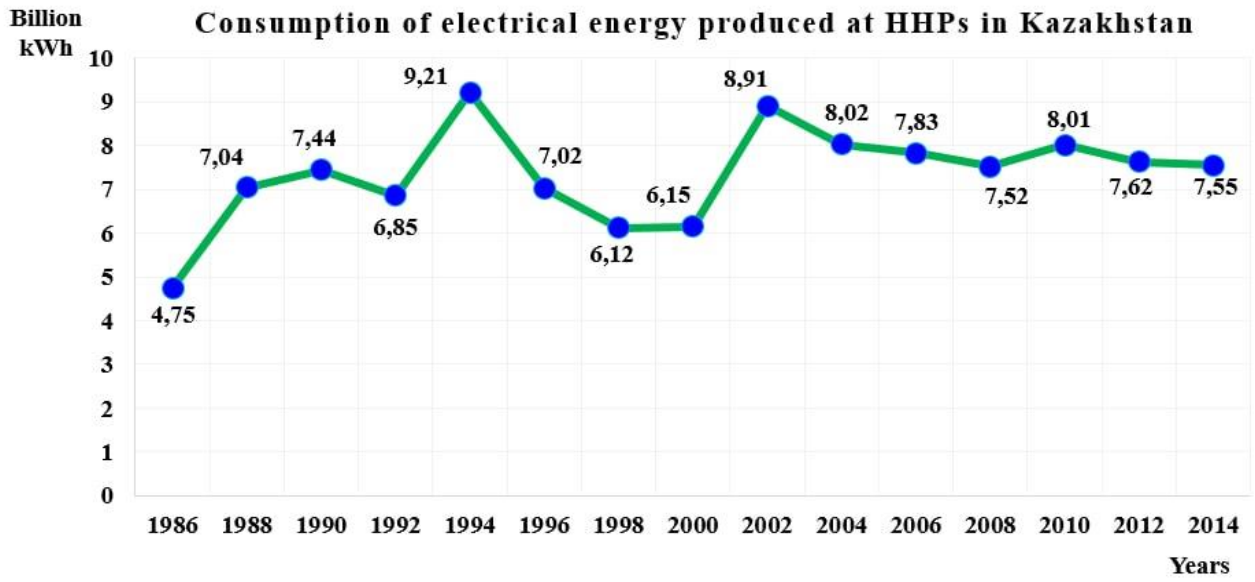

Figure 2. Consumption of electrical energy produced at HHPs in Kazakhstan

In Kazakhstan, there has not been word of any new big projects since the construction of Moynak HPP, but there are draft plans to build Bulak HPP (80 MW) on the Irtysh river and Kerbulak HPP (50 MW) on the O river. In the last 10 years seven mini HPP projects have been realised. Currently the Ministry of Investment and Development of Kazakhstan is open to investment in 3 HPP facilities: the Useksky HPP (25.6 MW), Chizhinsky HPP (49.6 MW) and Kiyat HPP (1.8 MW) [8].

The impetus for the construction in Kazakhstan of minor energy infrastructure objects, including mini HPPs, has been state support. The vehicles for this support are the provision of soft loans with minimal shared capital required from the borrower and an incentive-based tariff policy that forces grid operators to buy electricity from small hydropower plants, wind power plants, solar power and biogas installations at a fixed rate, indexed annually for a period of 15 years beginning in 2014. Under this scheme, minor HPP facilities sell electricity to the grid for no less than 16.71 tenge per kWh. By way of comparison, Kazakhstan's largest coal-based TPP – Ekibastuz GRES-1 – sells to the grid at just 8.8 tenge per kWh as of 2016. It is contend that small hydropower facilities are most suited to Kazakhstan's southern regions, where there are appropriate natural conditions for the construction of such stations [8].

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III. HYDROELECTRIC POWER PLANT (HPP) IN TAJIKISTAN.

Tajikistan's hydropower sector is the largest in Central Asia. According to the International Hydropower Association (2015), the total installed capacity of the local HPP sector is 5190 MW. According to the World Bank (2012), hydropower accounts for 99.6% of total electricity production in the country. In other words, hydropower is the sole and uncontested ruler of Tajikistan's electricity sector. The largest operating hydroelectric power station is Nurek (3000 MW), with other significant stations in the form of Baipazin HPP (600 MW), Sangtuda-1 HPP (670 MW) from 2008-14 and Sangtuda-2 HPP (220 MW). In addition to these larger hydropower plants Tajikistan operates 300 smaller hydropower plants [10].
HPP thus continues to dominate in two of the five Central Asian countries – Tajikistan and Kyrgyzstan – but their respective flagship projects remain in the balance amid political and investment uncertainty.

For as long as Rogun and Kambarata-1 remain politicized, their realization is difficult to foresee. Russia is hesitant to irritate the region's most populous country Uzbekistan by acting as a partner of the local governments on these projects. Tashkent has also refused to accept the arguments and proposals of its regional partners, and continues to stand its ground. In this situation, it would be more logical for Tajikistan and Kyrgyzstan to focus on projects that do not meet significant political resistance from Uzbekistan [12].

Examples of such projects include the Upper Naryn cascade. In Tajikistan, there are the successful examples of the Sangtuda HPP 1 and 2: the first station was supported by the Russians and the second by the Iranians. This indicates that the national hydropower segment is still somewhat attractive to investors [12].

IV. HYDROELECTRIC POWER PLANT (HPP) IN KYRGYZSTAN.

In Kyrgyzstan, hydropower accounts for 93.5% of electricity produced [9]. The total installed capacity of Kyrgyz HPPs according to the International Hydropower Association is an estimated 3091 MW. The largest hydroelectric power stations are Toktogul (1200 MW), Kurpsai (800 MW) and Tash Kumyr (450 MW). The most modern of the country's power stations is the Kambarata-2 HPP (120 MW), which was launched in 2010.
In Kyrgyzstan, the situation is a little different. The key projects as far as local officials are concerned are the Kambarata-1 HPP (1860 MW) and Upper Naryn cascade HPP (238 MW) projects. Both were initially slated for Russian investment, although the government has since cancelled agreements with two Russian companies amid lengthy construction delays caused by Russia's economic crisis. Finding new investors for these projects is a priority for the government despite the fact the country could add at least 200 MW of capacity by recovering 39 old HPP facilities and building 87 new mini HPPs). The Kambarata-1 mega dam project meanwhile has met strong resistance from the Uzbek side as it could "lead to a disruption of the water balance in the region" [9].

As of the end of 2019, total installed capacity stands at 3800 MW, of which hydropower is about 80% (11.5 TWh p.a., 10% of gross hydro potential). The government also launched a privatization program to develop the small and mini hydro sector projects up to 30 MW output. The largest hydropower stations in the country are Toktogul (1440 MW), currently under modernization, and Kurpskaya (800 MW). In addition, the government plans several new hydropower stations, i.e. Upper Naryn Cascade (237 MW), Kambarata 1 (1860 MW) and the Kazarman Cascade (1160 MW). For all above new facilities, international investors are presently being sought [11].

V. HYDROELECTRIC POWER PLANT (HPP) IN UZBEKISTAN.

The merged capacity of hydropower plants in Uzbekistan is 1731 MW and they generate 21.4% of the country's electricity [7]. Uzbekistan's hydropower segment yesterday was mainly represented by the 19 HPPs in the Chirchik-Bozsu cascade (Charvak, Hodzhikent, Gazalkent, Tavaksay, Chirchik, Bozsu etc.) with a capacity of 1200 MW. The first link in this cascade – Bozsu HPP – was built in 1926, and the last, Hodzhikent HPP, in 1977.

Some of the countries of Central Asia are moving in this direction. Faced with a prospective shortage of gas within the domestic energy system, the Uzbek authorities see a lot of potential in the modernization of existing hydropower plants and the construction of new, smaller hydropower plants [1]. According to the program of development of hydropower in

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Uzbekistan 2016-2020 19 HPPs were slated for modernization, "which will allow them to increase their total capacity to 100 MW and in addition generate 450 million kW/h of electricity while saving 200 million cubic meters of gas." If the projects are implemented, hundreds of small hydropower plants will generate another 1100 MW of capacity [1,7].

Total installed capacity stood at around 12,500 MW, of which hydropower contributed about 1,900 MW. There were 21 plants with a capacity of 10 MW or larger in operation, and 75% of the capacity was more than 40 years old [6]. In May 2017, a new state-owned hydropower producer and developer, "Uzbekhydroenergo" JSC, was formed and entrusted with implementing a five-year program for the development of the hydropower sector. The program envisaged the construction of 42 new plants and the modernization of 32 operating plants. In addition, the importance of pump storage power plants was growing [7].

The "Program of additional measures for further development of hydropower in 2021-2030" developed by the Ministry of Energy, the Ministry of Economic Development and Poverty Reduction, the Ministry of Water Resources, the State Committee for Geology and Mineral Resources, the Hydrometeorological Service Center, "Uzbekhydroenergo" JSC and other interested ministries and departments was approved in Uzbekistan on December, 2021 [1].

The Decree of the President of the Republic of Uzbekistan No. PP-44 dated December 10, 2021 identifies the following key areas for further development of hydropower in Uzbekistan, efficient use of existing hydropower potential, including the widespread use of environmentally friendly energy sources in the electricity sector [1]. It is planned to increase the capacity of hydropower plants in the country to 3,416 MW by 2030 by accelerating the creation of new capacities and the gradual modernization of existing production facilities. As a result, by the end of 2020, the power generation capacity of hydropower plants in Uzbekistan (in practice) amounted to 2,004.5 MW. The Figure 3 shows that forecast of commissioning of hydropower production facilities in Uzbekistan between 2021 and 2030 [1].

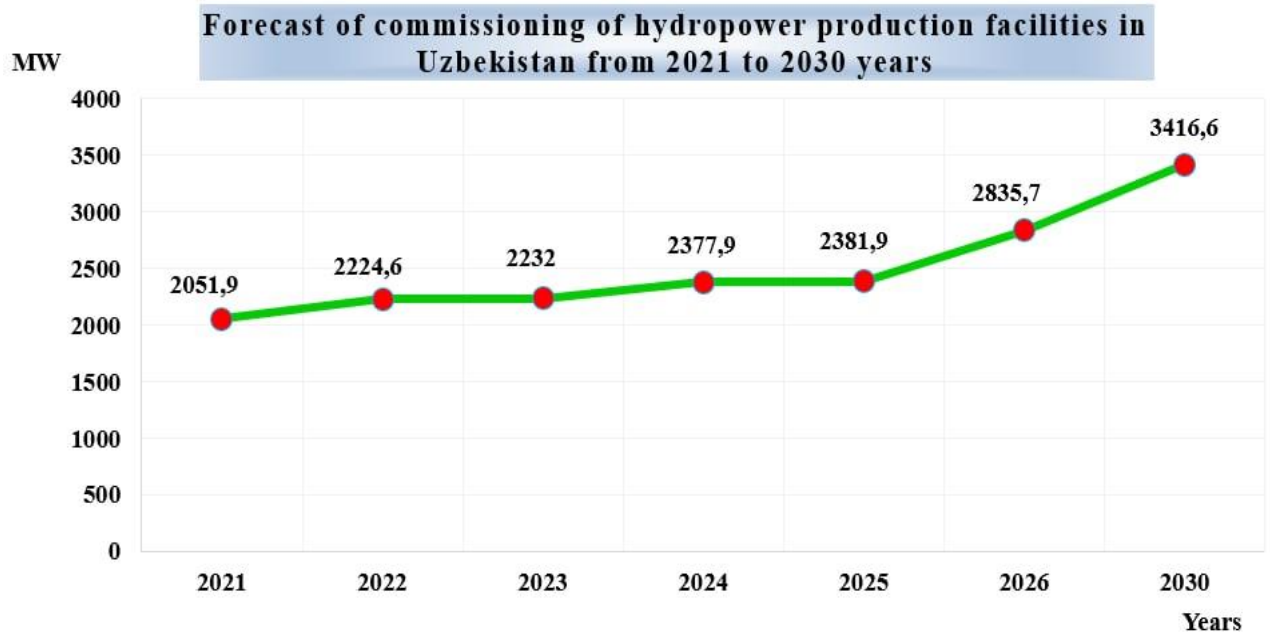

Figure 3. Forecast of commissioning of hydropower production facilities in Uzbekistan from 2021 to 2030 years (the data are given in MW)

Tashkent has raised similar complaints in regards to Tajikistan, which has been trying to build the 3600 MW capacity Rogun HPP for over a decade. The dam would accumulate up to 13.3 cubic kilometers of water from the river Vakhsh, which flows into the Amu Darya river that provides the main irrigation artery for Uzbekistan's strategic agricultural sector. A World Bank report shows that an operational Rogun HPP would not only increase electricity in the winter, but also contribute to increased production at Nurek HPP (by increasing the power of the turbine). The report's authors note

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the project "will be useful and will bring benefits to all the countries of the Amu Darya basin, if they can establish a precise inter-state agreement on optimization of multi-stage use; it will mark a significant improvement in electricity generation, irrigation and environmental objectives" [10].

VI. CONCLUSION

In conclusion, hydropower, which for the past decades has been one of the most significant segments of the power industry of Central Asia, has now hit a "political" ceiling. There is still some potential for the development of smaller HPP stations, but at the same time, the Central Asian countries are all in need of more diversity in terms of sources of energy. International organizations continue to focus on the potential of small hydro power plants, which the Central Asian countries have largely neglected. But even if this sub-sector grows it may take decades to influence the overall energy picture, and therefore cannot solve the very immediate problem of the winter energy deficits. Resultantly, there should be a complex and comprehensive solution to this problem, the elements of which are already discernible.

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