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MASTERING AND DEVELOPMENT HYDROPOWER IN KAZAKHSTAN

Abstract. The power characteristics of the constructed and operated hydroelectric power plants in Kazakhstan are given. It is shown that the share of electricity generated at hydropower plants in the total volume of electricity production in the country is still insignificant (8.4%, a), and the total installed capacity is only 2580 MW. Existing technological schemes of small hydropower plants require further improvements and new approaches in a constructive solution. It is indicated that the results of 80-85% of the research work performed are limited to the study of the parameters of prototypes or prototypes of improved and new HPP designs.

Existing promising domestic developments can serve as basic solutions for mastering them in production. It has been proposed to update the previously developed “Development Schemes for Small Hydroelectric Power Stations in Kazakhstan” on the basis of a feasibility study and an order of relations with local administrations for water use and land acquisition.

Key words: hydropower, hydroelectric power station, development, implementation, recommendations.

As you know, hydropower is the most common in practice and technologically mature industry in comparison with other known sources of renewable energy sources[1- 4]. This is due to the fact that during the construction and operation of a particularly small and mini hydroelectric station, the natural landscape is preserved, in many cases there is practically no stress on the ecosystem.

Hydroelectric power stations built in the hydropower system of Kazakhstan are mainly concentrated in the East Kazakhstan (East Kazakhstan), Almaty, Zhambyl and Turkestan regions of the republic [5, 6].

The East Kazakhstan region has the Shulbinsk Hydroelectric Power Station (702 Mw), the Ust-Kamenogorsk Hydroelectric Power Station (331 Mw), and the Leninogorsk cascade of hydroelectric power stations. MW), as well as a series of mini-hydropower plants: Aksu HPP-1 (1.9 Mw), Issyk HPP-2 and 3 (6.1 Mw), Karatal HPP-2, 3, 4 (11.9 Mw), Sarkand HPPs (0.5 Mw), Antonovskaya HPP-3 (1.6 Mw), Uspenovskaya HPP-4 (2.5 Mw), Intalinskaya HPP-5 (0.6 Mw). In the Zhambyl region there are Merke power stations-1, 2, 3 (3.6 Mw), Karakystakskaya HPP (2.1 Mw), Taso Keli HPP (9.2 Mw).

The installed capacity of the Shardara hydroelectric station, located in the Turkestan Oblast, is 100 Mw. It is currently being upgraded, according to the results of which the capacity should increase to 126 Mw.

At the same time, the Almaty region is considered one of the main producers of renewable energy sources from water resources, where by 2020 it is planned to develop 11 new projects, including a cascade of hydroelectric power plants with a total capacity of 42 Mw on the Koksu River and a single hydroelectric station with a capacity of 60.8 Mw on the Chilik River.

Since all hydropower plants of Kazakhstan have a relatively small capacity, their task is to regulate the load schedule, fulfilling the classic function of maneuverable power and “closing” consumption peaks. In such a configuration, the role of important elements of the power system, but not determining its development, remains behind the hydropower plants. Despite the fact that over the past 25-30 years, the total capacity of Kazakhstan's hydropower plants has grown, the overall level of electricity consumption produced on their turbines, according to BP Energy Outlook, by the mid-2010s after decades of ups and downs returned to the values of the late 1980s.

However, the share of electricity generated at hydropower plants in the total volume of electricity production in the country is still insignificant (8.4%, a), and the total installed capacity is only 2580 Mw, while in Tajikistan it is equal to 5190 Mw (figure 1).

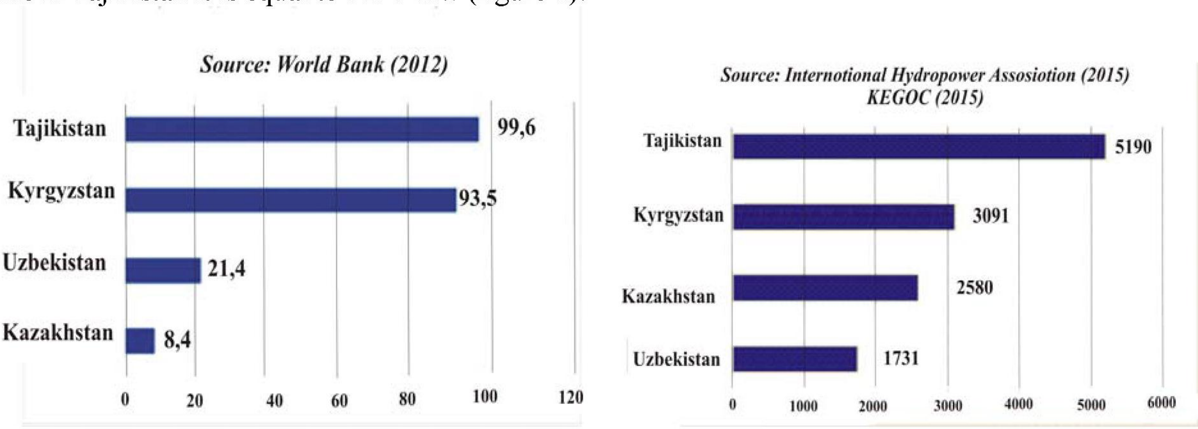


Figure 1 – The share of electricity generated at hydropower plants
in the total volume of electricity production in countries,% (a) and the total installed capacity, Mw (b)

As can be seen from these diagrams, these indicators are significantly inferior to the developed volume of energy of water resources of the countries of Central Asia [7].

The main problem in relations between the countries of Central Asia is the unbalanced system of water resources exploitation in the hydropower regime, during which winter floods are replaced by water shortages during the growing season of the main crops.

At present, Kazakhstan's hydropower potential is estimated at 170 billion kWh hours per year. According to experts, in the South it is possible to cover the shortage of electricity by building a cascade of environmentally friendly micro and mini hydropower plants, since the potential under consideration in this zone is estimated to be no less than 4 GW of power. Due to this, the share of development of available potential hydro resources in Kazakhstan, compared with the countries of Central Asia, increased slightly (figure 2, a) [8].

In 2017, the capacity of small hydropower plants in Kazakhstan increased by 30 MW due to the wide placement of numerous private power plants, such as Mankenskaya HPP (2.5 MW, 283 million tenge) in the Turkestan region (figure 2, b).

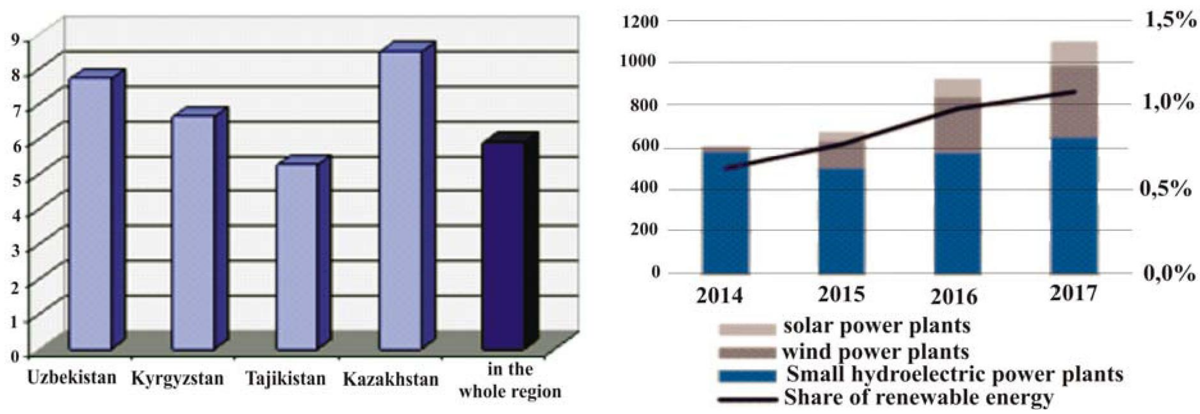


Figure 2 – Share of the use of potential hydro resources in the countries of Central Asia (a)
and production of electricity based on renewable energy sources in Kazakhstan

By 2020, Kazakhstan plans to build 41 small hydropower plants with a total capacity of 539 Mw, which will provide 17.6% of the total potential of renewable energy sources in Kazakhstan [9].

The feasibility of developing small hydropower industry in the republic is confirmed by the current trend in global hydro-construction experience. Due to the competitive price for electricity generated at small hydropower plants, they currently represent a very attractive business for investors.

The promising development of a small hydropower plant provides not only a reduction of the negative impact on nature, but also the full realization of positive factors, including integrated development of construction areas, regulation of weaving, creation of recreation areas, etc. from the mode of operation of the power system.

In this regard, in 2005, the Government of Kazakhstan developed and adopted a concept for the extensive construction of a small HPP with an annual electricity output of 4.8 billion kWh. The Law of the Republic of Kazakhstan "On Supporting the Use of Renewable Energy Sources" No. 165-IV of July 4, 2009 provides for the creation of favorable conditions for the construction and operation of facilities for the use of renewable energy sources.

The existing technological schemes of a small hydroelectric station with reference to the conditions of their use require further improvement and new approaches in a constructive solution[10-14].

In Kazakhstan, the development and design of hydropower plants began to be closely pursued in the 40s of the last century. This was facilitated by the demand for small hydropower in general and the creation of a branch of the All-Union design organization "Hydroproject" in Kazakhstan [6].

As a result, improved versions of the Almaty cascades of a small hydropower plant were developed and built, and successful work was continued on the efficient use of energy of water resources, especially South-East Kazakhstan.

Currently, more than 10 scientific organizations and educational institutions are involved in the development and research of small and mini hydropower plants. The leading ones are the Kazakh Research Institute of Energy, the KI Kazakh National Research Technical University. Satpayev, Institute of Energy and Communications, M.-H. Dulati Taraz State University, National Engineering Academy of the Republic of Kazakhstan.

The available groundwork on the subject matter of the research and technological areas is characterized as follows. Since 2010, on the basis of budget financing, 8 research projects have been carried out and innovative patents have been received for more than 40 inventions in the design of a hydroelectric power station, hydraulic units and for improving the methods of building and operating small hydropower plants. The results of 80-85% of the research work carried out are limited to studying the parameters of prototypes or prototypes of improved and new designs of hydroelectric power plants and hydraulic units in the laboratory.

Some designs have passed production tests. The derivational rotor mini hydroelectric station tested on the Turgen River (V.M. Nizovkin) with a rated power of 3 kW, with a head H = 20 m and a flow rate of 30 l / s with a pipeline length of 500 m showed the prospects of the chosen direction both in terms of costs and energy efficiency. It is focused on mountainous and foothill areas of the republic with river slopes of more than 50. According to the authors' calculated data, the development will reduce the cost of hydroelectric power plants from 350-700 US dollars / kW to 100-250 US dollars / kW at a cost price of 1 kW / h of electricity 0.05 - 0.4 US cents.

The following two developments with the name "Small diversion hydroelectric station" (№25130 RK, 2014, KazNRTU named after K.I. Satpayev) [15] and "Autonomous low-pressure mini-hydroelectric station with direct-flow turbine" (№13064 RK, 2003, KazNIIenergy) " [16] were studied under the program "Development of clean energy sources of the Republic of Kazakhstan for 2013-2017 within the framework of EXPO-2017" and their operating models were demonstrated at the exhibition EXPO-2017 and received positive feedback from experts from leading countries.

This first technical solution was also awarded the certificate and medal of the World Intellectual Property Organization (WIPO), as the best invention of 2012. The novelty lies in the improvement of the water supply unit of the existing small hydroelectric power plants using hydrocyclone grit catchers of intensive operation of a simplified design, which reduces the cost of building a water treatment unit from 30% (existing) to 7%.

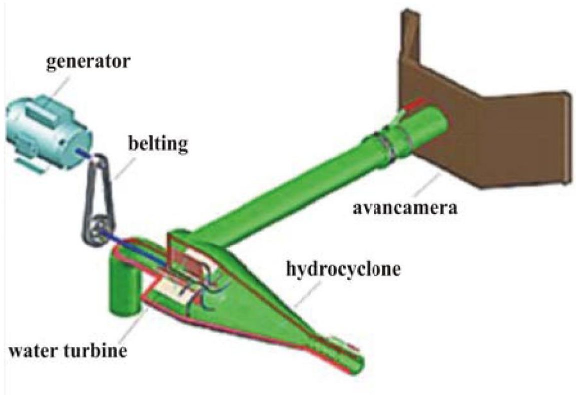
A prototype of a hydrocyclone with a diameter of 700 mm was tested under production conditions and it showed the degree of water purification from mechanical impurities up to 96-98%. The installed capacity of one used hydro-cyclone hydroelectric station is 3-10 MW. The calculated annual electricity generation reaches 4.0–5.0 million kWh.Due to the protection of the turbine against abrasive wear, its service life is significantly increased [17-19].

The advantage of the second development is to simplify the design and increase the reliability of operation of the unit operating as part of a small hydroelectric station. This is achieved due to the presence of a turbine, which is made of a cylindrical tube, inside which there are plates with the possibility of a smooth flow around it. The design feature of the blades of the water turbine contributes to the production of energy with a small flow of water, and also eliminates uneven rotation and vibration. There is no need for the construction of pressure structures.

In Kazakhstan, an invention was also developed with the name "Circulating mini-hydroelectric power station" [innovation patent KZ No. 29169.28.08.2013, TarGU after M.- H.Dulati] [20], characterized in that in the bottom of the cylindrical container there is an opening with a shell, in front of which is arranged a nano-scavenging galera, the output part of which passes under the bottom of the cylindrical container. At the same time, the supply of sediment in the annular sedimentation galarium is carried out tangentially.

However, in our opinion, the implementation of the water intake basin of the circulating action in the form of a cylinder to a certain extent reduces its separation capacity of sand from the incoming water and complicates the accumulation and removal of entrained mechanical impurities into the dump. The presence of a rectangular cross, on which the turbine is mounted, prevents rotation of the flow inside the cylindrical basin.

A new technical solution developed in the National Academy of Sciences of the Republic of Kazakhstan under the name "Hydroelectric power station of hydrocyclone type" (figure 3) increases the efficiency of the hydraulic unit, improves the power characteristics of the unit to 15-20% [21]. The degree of water purification in hydrocyclones when operating in pressure mode reaches 95-97%.



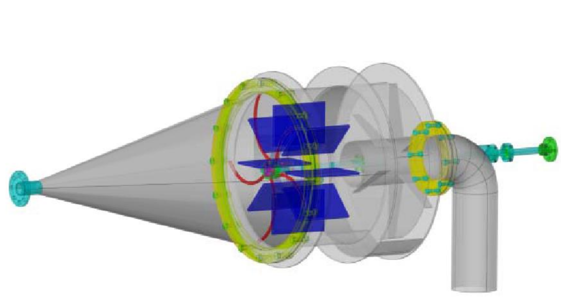


Figure 3 – General types of layout hydro hydroelectric mini hydroelectric type (a) and hydro turbines in a hydro cyclone body (b)

The simplicity of the design of the hydroelectric station and the technological layout design reduces manufacturing costs by up to 20%.

Here protection of the turbine against abrasive wear is achieved by the station's water intake being made in the form of a cylindro-conical hydrocyclone capsule, inside of which a lobed hydroturbine with a smaller diameter is located coaxially with a smaller diameter, the axis of the turbine is attached to the capsule by a discontinuous partition of curved plates spins of water tangentially supplied to the water intake.

This technical solution allows, in contrast to existing analogues, to use mini hydroelectric power plants in a capsule version and to master the hydrocyclone effect for separating the solid phase from the liquid when the water turbine is supplied.

The above improvement in power characteristics by 15-20% is achieved through the interaction of two surface swirling threads.

Conclusion. The generated capacity of hydroelectric power plants capable of covering peak loads is about 4% of the installed capacity of all hydroelectric power plants or about 5% of the capacity currently used. This proportion is not enough to cover peakloads.

Available promising domestic technical developments to a certain extent can serve as basic solutions for their development in the production. The introduction of such technological schemes, taking into account design features, will significantly increase the degree of development of economically justified hydropower resources in the Republic of Kazakhstan, which currently stands at 26 %.

This figure in economically developed countries ranges from 50-90% (in the US and Canada – 50-55 %, in Western Europe and Japan from 60 to 90 %).

It is necessary to update the previously developed "Scheme of development of small hydropower plants in Kazakhstan» on the basis of a feasibility study and the order of relations with local administrations on water use and land allotment. It is necessary to conduct a large-scale survey of existing and decommissioned small hydropower plants, develop recommendations to improve their performance and efficiency, reduce the cost of construction and operation. It is advisable to perform the optimization of the layout design of small hydropower plants considering the eco-geographical and economic factors.

The article is based on the results of the target program "Creation of the basis of serial production of renewable energy sources of Kazakhstan of world level" (BR05236263, NAS RK, 2018-2020).

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ҚАЗАҚСТАНДАҒЫ ГИДРОЭНЕРГЕТИКАНЫҢ ҚОЛДАНУ ЖАҒДАЙЫ ЖӘНЕ ДАМУЫ

Аннотация. Қазақстанда тұрғызылған және игеріліп жатқан гидроэлектростанциялардың қуаттық сипаттамалары келтірілген. Елімізде өндірілетін электр энергиясының жалпы көлеміне шаққандағы гидроэлектростанцияларда өндірілетін электр энергиясының үлесі бұрынғысынша төмен деңгейде (8,4%) және жалпы белгіленген қуаттылығы 2580 МВт-тен аспайтыны көрсетілген.

Пайдаланыстағы шағын гидроэлектростанциялардың қазіргі технологиялық сұлбалары жаңа жетілдірулерді қажет етеді. Ғылыми зерттеу жұмыстарының 80-85%-ы жақсартылған және жаңа ГЭС жобаларының тәжірибелік үлгілерінің параметрлерін анықтаумен ғана шектелген. Жаңадан жасалған перспективалық отандық техникалық шешімдер оларды өндірісте кең көлемде пайдалануға мүмкіндік бере алады. Бұрынғы Қазақстанда әзірленген «Шағын ГЭС-терді дамыту схемаларын» жаңартуды техникалық-экономикалық тиімділігін және суды пайдалану, құрылысқа жерді алу үшін жергілікті әкімшіліктермен өзара іс-қимыл тәртібінің негізінде қайта орындау ұсынылған.

Түйін сөздер: гидроэнергетика, гидроэлектростанциялар, дамыту, әзірлеу, енгізу, ұсыныстар.

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ОСВОЕНИЕ И РАЗВИТИЕ ГИДРОЭНЕРГЕТИКИ В КАЗАХСТАНЕ

Аннотация. Приведены мощностные характеристики построенных и эксплуатируемых гидроэлектростанции в Казахстане. Показана,что доля электроэнергии, вырабатываемой на ГЭС в общем объеме производства электроэнергии в стране еще незначительна (8,4%), а совокупность установленной мощности составляет всего 2580 Мвт. Существующие технологические схемы малой ГЭС требуют дальнейшего усовершенствования и новых подходов в конструктивном решении. Указаны,что результаты 80-85% выполненных научно-исследовательских работ ограничены изучением параметров макетных или опытных образцов усовершенствованных и новых конструкции ГЭС. Имеющиеся перспективные отечественные разработки могут служит базовыми решениями для освоения их на производстве. Предложено обновить ранее разработанные «Схемы развития малых ГЭС в Казахстане» на основе технико-экономического обоснования и порядка взаимоотношений с местными администрациями по водопользованию и отвода земель.

Ключевые слова: гидроэнергетика, гидроэлектростанции, развитие, разработка, внедрение, рекомендации.

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