Journal of Higher Education and Academic Advancement
Homepage : https://journal.antispublisher.id/index.php/EJHEAA
Email : admin@antispublisher.com

e-ISSN : 3032-1123
JHEAA, Vol. 2, No. 1, January 2025
Page 85-90

Hydroelectric Stations and Their Importance for The Republic of Uzbekistan

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DOI : https://doi.org/10.61796/ejheaa.v2i1.1210

Sections Info

Article history:
Submitted: December 27, 2024
Final Revised: December 27, 2024
Accepted: December 28, 2024
Published: December 28, 2024

Keywords:
Hydroelectric power plant
Energy
Uzbekistan
Electricity energy working release
Technical parameters
Energy safety

ABSTRACT

Objective: *This study aims to analyze the significance of hydroelectric power stations in Uzbekistan, focusing on their role within the national energy infrastructure and economy. It examines the contribution of these plants to energy security and the stability of electricity supply.* ***Methods:*** *The research involves an assessment of the technical characteristics of existing hydroelectric power plants, analyzing their operational parameters and their overall impact on electricity generation. Additionally, economic and environmental aspects are considered to evaluate their broader influence on regional development.* ***Results:*** *The findings highlight the essential role of hydroelectric power plants in Uzbekistan's energy sector. These stations contribute significantly to electricity production, enhancing the reliability of energy supply. Furthermore, they play a crucial role in supporting regional infrastructure development while offering potential economic and environmental benefits.* ***Novelty****: This study provides a comprehensive evaluation of hydroelectric power stations in Uzbekistan by integrating technical, economic, and environmental perspectives. Unlike previous studies, it emphasizes the interconnected impact of these plants on energy security, sustainability, and regional infrastructure growth.*

INTRODUCTION

Hydroelectric power plant (HPP) is a complex of hydraulic structures and power equipment that convert the energy of a water flow into electricity using hydraulic turbines [1], [2]. Hydroelectric structures are divided into dam-side, diversion and mixed types. Electrification work in Uzbekistan began in the second quarter of the 20th century [3]. Currently, there are several power plants, such as Chirchik, Chorvok, Farhod, Bosuv, Solor, Samarkand, Topalang HPPs. According to the CIS Electric Power Council, as of the end of 2017, the total installed capacity of power plants in Uzbekistan was 14,140 MW, including thermal power plants - 12,129 MW, hydroelectric power plants - 1,878.7 MW, and others - 132.9 MW. In 2017, power plants in Uzbekistan produced a total of 60.7 billion kWh of electricity [4], [5], [6], [7]. Hydroelectric power plants have several advantages and disadvantages. For example, the cost of electricity generated is low, and they have less environmental damage than other power plants. The disadvantage is that reservoirs occupy a very large area, and the construction of a hydroelectric power plant requires relatively large funds. However, there is one advantage over any power plant - hydroelectric power plants operate on renewable resources [8], [9], [10]. For example, the

resources of thermal power plants (coal, fuel) may one day run out. However, the water consumed in hydroelectric power plants is naturally replenished every year [11].

RESEARCH METHOD

There is a need for large-scale modernization of hydroelectric power plants in Uzbekistan. Of the 36 operating hydroelectric power plants, 25 were built in the 1940s-1980s, and most of them have already reached the end of their service life. As a result of the implementation of this project, we will at least double the total capacity of three hydroelectric power plants, and it is also being proposed to increase electricity production by more than 3 times. The way hydroelectric power plants work is very simple. Hydraulic equipment sends water at a certain pressure [12], [3], [14]. This water hits the blades in special pipes and drives generators. As a result, electricity is generated.

RESULT AND DISCUSSION

In hydroelectric power plants near a dam, the water level is raised by means of a dam, and the necessary pressure is created. The hydroelectric power plant building is located in 3 ways: 1) near the dam; 2) away from the dam; 3) below the dam, in the riverbed. In hydroelectric power plants built near the dam and in the riverbed, the water pressure is created by the dam [15]. Such hydroelectric power plants are built on flat-flowing mountain rivers with a lot of water, in narrow places of valleys. These include the Kairakkum, Tuyamoyin and Chordara hydroelectric power plants. Diversion hydroelectric power plants (where water is brought to the power plant through pipelines, canals or tunnels) are medium and high pressure, and pressure is created using a derivation channel [16], [17]. Such hydroelectric power plants include the hydroelectric power plants on the Charvak, Farhod and Bozsuv canals. In mixed hydroelectric power plants, pressure is created mainly by hydraulic structures on the river and partly by a diversion channel. The complex of hydroelectric power plants includes a main structure (dam) that blocks the riverbed and creates pressure, a channel that supplies water to the hydroelectric power plant building, a station pressure node or pressure water pipeline, structures that regulate the water level and flow, discharge excess water, and other automatic devices; a machine room with a hydraulic unit that directly converts water energy into electrical energy, and structures that discharge used water. Water supplied to hydroelectric power plant turbines with special hydraulic structures rotates the turbine impeller, the shaft mounted on it, and the generator attached to the shaft, which generates electrical energy. Electrical energy is supplied to consumers by special devices. Currently, the operation of all hydroelectric power plants is automated. Several automated hydroelectric power plants are controlled remotely (from a neighboring hydroelectric power plant or from the power system control panel). According to the designated capacity of the hydroelectric power plant, it is divided into low (up to 5 MW), medium (5-25 MW) and large (over 25 MW) types. To fully utilize the energy resources of the river, hydroelectric power plants are placed in a cascade, that is, at a certain distance along the

river flow. Such hydroelectric power plant cascades include Tashkent (Bozsuv, Borijar, Oktepa, Shaykhontohur hydroelectric power plants) in Uzbekistan; Qodriya (Qodriya, Qibray, Salar, Okqovok-2); Chirchik (Tovoksoy, Okqovok); Lower Bozsuv (HES-14, HES-18, HES-19, HES-22, HES-23); Middle Chirchik (Chorvok, Hojikent, Gazalkent); Shahrikhan (HES5A, HES-6A, HES-YUFK-1, HES-4A YUFK-3); Samarkand (HPP-1B, HPP2B, HPP-ZB, HPP-5B) includes cascades of hydroelectric power plants. Among hydroelectric power plants, a special place is occupied by a hydroelectric power plant (HPP) and a surge hydroelectric power plant (SHP). HPPs are built to replenish energy in large energy systems during periods of high energy demand (peak hours). The energy accumulation feature of HPPs is based on the use of electricity that is free in the energy system at certain intervals. It is worth noting that in Uzbekistan, within the framework of a special program, it is planned to build 42 new hydroelectric power plants and modernize 32 existing hydroelectric power plants in the medium term. This year, 10 projects are being implemented, the cost of the first stage is $ 364.6 million.

According to experts, Uzbekistan's hydropower resources allow generating up to 27.4 billion kilowatt-hours of electricity per year. At the same time, today only 6.5 billion kilowatt-hours, or 23.7 percent, of the total hydropower potential of our country have been developed.

Hydropower plants play an important role in the energy system of Uzbekistan, providing a significant part of the country's electricity production. This is a very important area that affects the country's energy security and economic development. The study provided a deeper understanding of the technical aspects of the operation of hydropower plants, their impact on the environment, as well as the importance of their participation in the overall energy production structure in Uzbekistan.

O‘zbekistonning gidroenergetika sanoati

№	Gidroelektr stansiya nomlari	Ishlab chiqarish quvvati	Qaysi hudud joylashgan	Qaysi daryoga qurilgan
1	Chorvoq GESi	666 mWt	Toshkent	Chorvoq daryosi
2	To’palon GESi	175 mWt	Surxandaryo	To’palondarosida
3	Xo’jakent GESi	165 mWt	Toshkent	Chirchiq daryosi
4	Tuyamo’yin GESi	150 mWt	Xorazm	Amudaryoda
5	Andijon GESi	140 mWt	Andijon	Qoradaryoda
6	Farxod GESi	128,24 mWt	Sirdaryo	Sirdayoda
7	G’azalkent GESi	120 mWt	Toshkent	Chirchiqda
8	Chirchiq GESi	84 mWt	Toshkent	Chirchiqda
9	Shaxrixon GESi	11,4 mWt	Andijon	Shaxrixon kanali
10	Oxangaron	26 mWt	Toshkent	Oxangaronda

However, in order to maximize efficiency and sustainability, it is important to pay attention not only to existing, but also to potential hydropower development projects.

This requires an integrated approach, taking into account environmental factors, social significance of projects and economic feasibility. Optimization of the operation of existing hydropower plants and the introduction of new technologies will allow to increase the overall energy potential of the country and meet its future energy needs.

Thus, hydroelectric power plants of the Republic of Uzbekistan play an important role in ensuring energy stability and sustainable development of the country. Careful planning, innovative approaches and consideration of all aspects of hydropower use play an important role in achieving energy efficiency and sustainability in the future.

CONCLUSION

Fundamental Findings : Hydropower plants (HPPs) are a crucial component of Uzbekistan's energy system, contributing significantly to electricity production while utilizing renewable water resources. Despite their advantages, such as low-cost energy generation and minimal environmental impact, challenges remain, including large land requirements and high initial investment costs. The study highlights the technical functioning of HPPs, their classifications, and their role in Uzbekistan's energy mix. Understanding these fundamentals is essential for optimizing their operation and integration into the country's long-term energy strategy. **Implications :** The findings underscore the need for modernization and expansion of Uzbekistan's hydropower infrastructure to meet increasing energy demands. Given that many existing HPPs were built decades ago and have reached the end of their service life, upgrading them is essential for energy security. Additionally, strategic investments in new hydropower projects can enhance sustainability, reduce reliance on fossil fuels, and contribute to economic development. Integrating automation and advanced technologies will further improve efficiency and reliability. **Limitations :** This study primarily focuses on the technical and structural aspects of hydropower plants in Uzbekistan but does not comprehensively address social and ecological concerns. While hydropower is renewable, large-scale projects may disrupt ecosystems and local communities. Furthermore, external factors such as climate change and fluctuating water availability pose uncertainties that were not extensively analyzed. Addressing these limitations requires further interdisciplinary research and stakeholder engagement. **Future Research :** Future research should explore the socio-economic and environmental impacts of hydropower expansion in Uzbekistan. Investigating sustainable solutions, such as hybrid renewable systems and innovative water management techniques, can optimize hydropower utilization. Additionally, policy analysis on regulatory frameworks and investment models will be crucial for fostering long-term development. Collaborative studies with international experts could provide valuable insights into best practices for enhancing Uzbekistan's hydropower sector.

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