

DETERMINATION OF DESIGN PARAMETERS AND COST-EFFECTIVENESS OF SMALL HYDROPOWER PLANTS

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Abstrakt

The article presents the role and significance of small hydroelectric power plants in the world energy industry and methods for determining its economic parameters. Today, data are provided on the economic parameters of small hydroelectric power plants being built in the world, in the Republic of Uzbekistan. The method and calculation results of determining the cost-effectiveness of hydroelectric power plants under construction by comparing annual costs are presented.

Key words

Hydroelectric Power Station, Hydroelectric Power Station, Hydroelectric Power Station, Hydroelectric Power Station, Hydroelectric Power Plant.

Introduction. Today, small hydroelectric power plants in the world energy industry have a mature technology and management system, so the process of energy production has a minimal impact on the environment, it is economically feasible, small hydroelectric power plants (HYDROPOWER plants) are completed in a short time, their reservoirs do not occupy a large area [1,2,3].

Small hydropower makes a great contribution to solving the problems of electrification of residential areas in many regions of the world where centralized energy supply is not possible or requires large investments, helping to improve the living standards and production conditions of the population. KGESs can be built in almost any water source and facility with hydropower potential, even without the use of pipes and pipes, there are small power units that operate only at the expense of the kinetic energy of the water flow [1,2,3].

A new study has shown that the use of microgrids in the field of microgrids is an important factor in their development [4]. It is important to note that this is primarily due to the use of renewable energy sources, including the use of hydroelectric power plants, the rational use of energy resources, the acceleration of their volume, the need for accumulation and the calculation of their distribution. According to the World Energy Agency (ANC), the country's energy sector will

have 30 million renewable energy sources by 2030. About 40% of the population is Edward Snowden [5].

In the Republic of Uzbekistan, on the basis of energy development, a large-scale work is being carried out to provide the sectors of the economy and the social sphere with full and high-quality electricity.

In accordance with the Decree of the President of the Republic of Uzbekistan dated September 9, 2022 No. UP-220, it is planned to build micro and small hydroelectric power plants with a capacity of 56,562 kW and generating 202702 thousand kWh of electricity per year, as well as with a capacity of 26.6 MW and 110.6 million kWh of electricity per year according to the Decree of the President of the Republic of Uzbekistan dated 12/12/2024 №. PQ-252.

It is important to note that this is not only a significant step forward in the development of the country's natural resources, but also in the development of hydropower facilities (hydroelectric power plants, hydroelectric power plants and canals). The use of hydroelectric power plants in the construction of hydroelectric power plants has led to a decrease in the cost of hydrogen and the cost of hydrogen [6]. Hydropower The Hydropower Plant of the Republic of Kazakhstan is considered a significant source of energy, and the energy efficiency of the hydroelectric power plant is considered a significant source of energy and energy.

The development of small hydroelectric power plants was recognized as a priority area in the World Small Hydropower Development Report 2019 prepared by the United Nations Industrial Development Organization (UNIDO) and the International Centre for Small Hydropower (ICSHP) and highlighted the need to make full use of its existing potential in countries [7]. According to the 2022 report of the above-mentioned organizations, the total capacity of small hydroelectric power plants has now exceeded 80 GW [7].

According to Global Market Insights, the capacity of small hydroelectric power plants increased to 350.6 MW in 2024 and is predicted to reach 429.8 MW by 2034 [8].

Materials and styles. At the initial stage of feasibility study of projects of small hydroelectric power plants, it is important to be able to determine approximately the amount of capital investments for their construction [3].

The project cost is determined during the feasibility study, design and construction. The capital expenditure of the SPP is determined taking into account the fixed capacity and the cost of the NPP. Therefore, the total capital expenditure required for a hydroelectric power plant, which includes all components except for the funds spent on power lines, can be determined using the Gordon formula [3].

$$K = 9,1 \cdot \theta \cdot \left(\frac{N_1}{H_1^{0,21}} \right)^{0,8}, N_1 = \frac{N}{N_0}, H_1 = \frac{H}{H_0} \quad (1)$$

It is estimated *that K is* the capital investment in the hydroelectric power plant (million dollars), *N* is the estimated capacity of the hydroelectric power plant (kW), *H* is the pressure of the hydroelectric power plant (m), *H1* is the design parameters, *N0* = 1000 kW, *H0* = 1 m are the main parameters, *θ* is the local calculation conditions, *θ* = 0.3...1.0.

This disambiguation page lists articles associated with the title N. According to the International Agency for Renewable Energy Sources (IRENA) annual renewable energy production expenditures for 2024, the specific cost of funds spent on the construction of large hydroelectric power plants in 2023 will be 2806 dollars/kWh and this figure will be 4216 dollars/kW for small hydroelectric power plants [9]. However, this publication emphasizes the need to verify this number for small hydroelectric power plants from other sources due to the scarcity of data.

According to the above agency, in 2016 and 2023, the lowest costs for large hydroelectric power plants were in India - an average of \$1586/kW, and the highest value was \$2608/kWh in South American countries [9].

According to the target parameters of the Program of measures for the further development of hydropower in the Republic [10], the approximate cost of investment projects for the construction of new hydroelectric power plants in natural water flows and water management facilities is on average 2330 dollars/kW, that is, the minimum value is 1000 dollars/kW of the Verkhnepskom hydroelectric power plant on the Pskom River, the maximum value is 4300 dollars/kW (small hydroelectric power plant on the 39 + 19 peak of the Dargam canal). At the same time, with an increase in the capacity of the SPP, its cost decreases, for example, when the capacity of the SPP is up to 50 MW, the average specific value is 3150 dollars/kW, and if the power is above 50 MW, it is 2060 dollars/kW.

One of the ways to determine the cost-effectiveness of small hydroelectric power plants is to compare the total annual costs incurred at the hydroelectric Σ power plant (YXHEPS) with the annual costs of another power plant of the same capacity. In large capacity HEPPs, thermal power plants (IES) are accepted as other power plants, and in small HEPPs, diesel power plants (DES) are accepted.

At the same time, the construction of the SPP is considered cost-effective in case of the following inequality.

$$\sum \tilde{I}X_{GES} < \sum \tilde{I}X_{DES} \quad (2)$$

Annual Estimated Expenses of the SPP The $\sum \tilde{I}X_{ГЭС}$ mainly consists of [3]

$$\sum \tilde{I}X_{ГЭС} = \tilde{I}X_{фой.} + r \cdot K_{ГЭС} \quad (3)$$

Bund, $\tilde{I}X_{фой.}$ - Annual utilization (operation) of the SPP.

$K_{ГЭС}$ is the amount of capital expenditure on the construction of a hydroelectric power plant.

r - Real Bank Foiz Yoki Discount Rate.

$\tilde{I}X_{фой.}$ The amount can be defined as [3]

$$\tilde{I}X_{фой.} = \tilde{I}X_{ам} + \tilde{I}X_{жт} + \tilde{I}X_{суге} + \tilde{I}X_{ух} + \tilde{I}X_{тх} + \tilde{I}X_{чттт} + \tilde{I}X_{бх} \quad (4)$$

At the same time, $\tilde{I}X_{ам}$ - depreciation of hydroelectric power stations;

The S&P 500 has been hit hard by the S&P 500;

$\tilde{I}X_{жт}$ - insurance costs for hydroelectric power plants;

$\tilde{I}X_{суге}$ - salary expenses;

$\tilde{I}X_{ух}$ - transport kharajatlari;

The S&P 500 is the S&P 500;

$\tilde{I}X_{бх}$ - Be careful.

These costs are accepted on the basis of the norms set out in the departmental regulations. $\tilde{I}X_{фой.}$ in the early stages of the GES project. *The total cost can be accepted in the amount of (0,01...0,04)KGES for hydropower plants on the basis of the guidelines for projects and investors in the field of hydropower, published by the consulting company Fichtner Management Consulting AG of the International Finance Corporation [11].*

The amount of investment required for SPPs, which can also be called capital funds or the estimated cost of the SPP, includes not only the costs of its construction, but also the costs of other necessary purposes [3].

$$K_{ГЭС} = K_{лқи} + K_{қур} + K_{ёоб} + K_{ижт} + K_{эко} \quad (5)$$

At the same time, $K_{\text{Ақу}}$ – project – expense of exploration;

$K_{\text{қуу}}$ - costs for construction and installation work (including the purchase of equipment);

Queen’s Platinum Jubilee Medal of Honor (Queen’s Platinum Jubilee and Queen’s Platinum Jubilee). I’ve been thinking about using the Smash Bros. Ultimate Edition for the Smash Bros. Ultimate Edition;

$K_{\text{ұжт}}$ - expenses for social facilities and events;

Coco is an environmental measure used for environmental measures.

The estimated costs of diesel power plants Σ can be summed up as follows

$$\Sigma \tilde{YX}_{\text{ДЭС}} = \tilde{YX}_{\text{әқу}} + \tilde{YX}_{\text{mp}} + \tilde{YX}_{\text{фoй}} + r \cdot K_{\text{ДЭС}} \quad (6)$$

At the same time, *it* is the cost of fuel;

YX_{tr} - transport costs for transporting fuel;

Y_{hfoi} is a beneficiary of DES.

R is the real interest rate on bank loans.

Using the method of determining annual costs, we determine the efficiency of the SPP on the basis of the following example [3].

Results. We determine the annual estimated costs of a hydroelectric power plant with a capacity $N = 5000$ kW and compare it with the costs of a diesel power plant with this capacity. For both options, we take the bank's real interest rate $r = 15\%$, and according to the formula (3), the current expenses of the SPP are equal to .

$$\Sigma \tilde{YX}_{\text{ГЭС}} = \tilde{YX}_{\text{фoй}} + r \cdot K_{\text{ГЭС}} = 0,576 + 0,15 \cdot 14,4 = 2,736 \text{ million dollars.}$$

We assume $K_{\text{ГЭС}}$ at 2,806 USD/kW based on the average specific cost of capital in 2024 [9]. So, $K_{\text{ГЭС}} = 2806 \cdot 5000 = 14.03$ million dollars.

$\tilde{YX}_{\text{фoй}}$. We accept 4% of KGES on [11],

$$\tilde{YX}_{\text{фoй}} = 0.04 \cdot \text{CHPP} = 0.04 \cdot 14.03 = 0.561 \text{ million dollars.}$$

$$\text{From this } \Sigma \tilde{YX}_{\text{ГЭС}} = 0,561 + 0,15 \cdot 14,03 = 2,665 \text{ million dollars.}$$

Diesel Electric Station (6) is a formula for aniqclaimiz.

We determine the cost of operation of a diesel power plant by the following formula.

$$\tilde{YX}_{\text{фoй}} = a \cdot K_{\text{ДЭС}} = 0.064 \cdot 1000000 = \$64000.$$

$K_{ДЭС}$ is a diesel power plant and the capital investment required,

$$K_{ДЭС} = N_{ДЭС} = 200 \cdot 5000 = 1000000 \text{ dollars.}$$

$a=200 \text{ USD/kW}$ – Specific cost of DES [12]

$a=6,4 \%$ – % of operating expenses [12]

$$\tilde{YX}_{\ddot{K}\mu} = c \cdot \theta \cdot \mathcal{E} = 0.5 \cdot 0.25 \cdot 35\,000\,000 = 4375000 \text{ USD.}$$

At the same time, the price of S – 1 liter of diesel fuel, Dollar.

c – 1 kW · h of electricity is used to generate electricity. $\theta = 0.22 \dots 0.27 \text{ l/kWh.}$

[12]

\mathcal{E} – The number of people affected by the pandemic has increased significantly per kW · h.

$$\mathcal{E} = N_{ДЭС} \cdot T_{ДЭС} = 5000 \cdot 7000 = 35\,000\,000 \text{ kW} \cdot \text{soat}$$

Transportation costs account for 10% of fuel costs[11]

$$\tilde{YX}_{mp} = 0,1 \cdot \tilde{YX}_{\ddot{K}\mu} = 0,1 \cdot 4375000 = 437500 \text{ dolls.}$$

Loan amount in the amount of $r \cdot K_{ДЭС} = 0.15 \cdot 1000000 = 15000 \text{ dollars.}$

Annual expenses for total DES will be equal to the following value

$$\sum \tilde{YX}_{ДЭС} = 4375000 + 437500 + 64000 + 15000 = 4.8915 \text{ million dollars.}$$

Therefore, the construction of the SPP is considered expedient as the annual costs of the SPP are almost 1.8 times smaller than the annual costs of a diesel power plant.

Conclusion.

1. Analysis of the importance of the Kichik hydroelectric power plants in the energy sector and the economic parameters of the Kichik hydroelectric power plant as a cost-effective, environmentally friendly and reliable source of energy.

2. It is believed that the economic parameters for the construction of small hydroelectric power plants in the Russian Federation are currently being established.

3. A methodology for determining the cost-effectiveness of SPPs by the annual cost comparison method was recommended. The results of calculations performed on the basis of this methodology showed the cost efficiency of a hydroelectric power plant with a capacity of 5 MW.

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