UDC 621.311.21

ECONOMY OF BUILDING OF SMALL HYDROPOWER STATIONS

N.A. Palishkin, candidate of technical sciences
I.A. Mishchenko, Ph.D.

Conducted comparative analysis of the economic performance of small hydroelectric power plants of various types. Shown that the use of types of projects and serial hydropower equipment allows to reduce by one third the cost of construction of small hydro power plants.

The unit costs, efficiency, hydro electric station, the turbine, the dam, power.

The economic performance of small hydropower stations (SHP) depend on the type of hydro - built a new hydroelectric or upgraded and remodeled existing one. Great influence on the economic performance of small hydropower plants has the level of standardization of the existing hydropower equipment - individual or batch. In some cases, a turbine pump can be used, mass-produced for other purposes. Some impact on the economic performance of small hydropower plants can have a typing design solutions, automation of design documentation

The purpose of research – discover factor which may influence s' on the economic efficiency of the construction and reconstruction of small hydropower stations.

Materials and method of research. Use general and specific scientific methods: a comparative analysis, systematization and generalization.

The result of research. According to a number of foreign firms (for example, firms «Allis - Chalmers») unit costs for newly constructed hydroelectric power plants (HPP) capacity up to 10 MW at 1100 ... $ 1,400 / kW, and for hydro power up to 1 MW - 6800 ... 8700 $/KW. For the plant entered in the operating hydropower, unit costs are 500 ... 2000 $ / kW.

In Switzerland, the unit cost of construction of small hydropower plants is 1,800 ... $ 2,300 / kW in England - up to $ 2,500 / kW in Japan – 2300 ... $ 3,000 / kW. In the U.S., sensible performance of thermal power plants (TPP) on the organic top about – $ 1,500 / kW, nuclear power station (NPS) – $ 2,000 / kW, the largest hydroelectric power station's – 1750 $ / k W [6]. In this case, the cost of 1 kW of electricity produced is: the power plant up to 10 MW – 0,018 0.024 $. It follows that the cost of electricity produced by small hydropower plants is comparable, and often, and lower the cost of electricity generated by thermal power plants.

Cost per unit at SHP in Ukraine in the 80-ies of the last century changed depending on the power – 200 ... 1300 rubles / kW. In most cases, this value does not exceed 600 ... 700 rubles / kW and only under particularly difficult conditions of the construction of specific capital investments exceed 1000 rubles / kW [3].

With the decrease of power of SHP specific investment increases, and, particularly hydroelectric power at significantly less than 100 kW (hydroelectric power 23 ... 100 kW unit cost s of 1000 ... 3610 rubles / kW) [3].

Most expensive are riverbed plants. And its value is higher up to 5 ... 10 % in comparison to hydropower dam plants. The lowest capital investment required for the construction of diversion hydropower plant, which cost an average 10 % cheaper than hydropower dam plants.

Cost of electricity varies from 0,2 to 2,6 UAH / (kW · h). The lowest cost of hydroelectric power had those stations, the power of which were more than 1000 kW. Currently in two hydropower stations with the capacity of 175 and 327 kW electricity costs up to 1,56 UAH / (kW · h). The construction costs structure for small hydropower stations is different than for large hydro hydropower stations.

Thus, the cost of processing equipment of small hydropower stations are comparable with the cost of construction, and, sometimes exceed it. This is evident from a comparison of the cost structure of large and small hydro power plants according to the International Electrotechnical Commission [2] (Table 1).

1. Cost structure for large and small hydropower stations

Power / pressure hydropower stations	Cost Structure,%		
	Construction and installation work	equipment	design
MW 625/16 m	80	15	5
1.5 MW / 14 m	30 – 35	50 – 60	10 – 15

In the case of construction of small hydropower stations in the final waterfront and the construction of a new alignment of the investments are as follows (Table 2).

2. Cost structure for small hydropower stations in the reconstruction and new construction

Waterworks	Cost Structure,%					
	Construction work	The main hydro power equipment	Design and survey work	Unforeseen costs	Accessory equipment	Other equipment
Small hydropower stations in the ready-pressure front	15	39	20	10	11	5
Small hydropower stations in the new alignment	45	18	20	10	4	3

The cost structure defined by 25 built in China small hydropower stations with capacity from 150 ... 2500 to kW (H = 4.2 ... 612 m) is as follows: construction work – 42 ... 65 %, equipment – 31 ... 48%, the construction of power lines – 4 ... 14 %.

The structure of the tour cost for the construction of small hydropower plants In Finland, obtained on the basis of the analysis and design studies of 50 hydropower plants, is shown in Table. 3.

3. Structure of costs for the construction of small hydropower stations in Finland.

Power SHP MW	Cost Structure,%				
	HPS building	The dam and water lines	Enginery	Electrical equipment	other expenses
5	19	21	29	17	14
5 ... 10	25	22	19	17	17
more than 10	21	18	18	15	28

In Ukraine, the cost of small hydropower stations distributed as follows: waterworks – 48.7 % the power intake – 24.7%, hydro-mechanical and electrical equipment – 22.6 % [5].

Technical and economic performance of small hydroelectric power station is improved by the integrated use of hydroelectric complex of the power plant. According to the calculations of the American firm «Allis-Chalmers» if you have finished waterfront unit investments in hydropower reduced by 30 ... 50 % helps reduce the cost of small hydropower use of standard and typical solutions. Effect from the introduction of standardized equipment can rich 10 ... 50 % of total costs for the equipment.

An important factor in improving the efficiency of the design and construction of small hydro power plants is term reduction. Due to the wide use of standard and unified projects, many foreign firms provide input to the power plant operation in 12 ... 15 months after receipt of order [2].

As the experience of the construction of small hydropower plants in the Ukraine, the project construction period, depending on the local conditions was 1 ... 2 years. However, in most cases, these terms are stretched by 3 ... 8 years. Apart from reducing construction time, the use of standard designs to reduce the cost of the project small hydropower plants. Therefore, standardization of design solutions for small hydropower plants is an urgent task.

Table. 4 shows the structure and costs of small hydropower plants (N = 500 kW, N = 18 m ready-pressure front) depending on the design [3].

4. Difficult structure of small hydropower plants on the individual and typical types of projects (according to the company «Allis - Chalmers»)

Expenditure	Cost *	
	And ndividualny project	T ipovy project
Turbine	150/30	140/37
Design	130/26	40/11
Multiplier	45/9	40/11
The gate at the entrance	40/8	35/9
Hydraulic structures	35/7	25/8
Other structures	100/20	95/25
Total	500/100	375/100

* – In the numerator cost – thousand dollars, in the denominator – %

Many foreign companies believe that the use of standardized (typical) projects is possible only for small hydro power up to 5 MW. Construction of small hydropower plants more power should be based on individual projects.

According to the data of American experts cost of construction of small HPPs with standard equipment increases with decreasing pressure and increasing power plant. This conclusion is confirmed by the data on the cost in construction of small hydropower plants in Norway.

In order to reduce the cost of construction of small hydro power plants is underway to reduce the cost of design, construction and operation. To do this, foreign firms in the design stage small hydropower plants are widely used standard layout solutions, unified energy and hydro-mechanical equipment, standard, mass-produced by industry, parts and products.

Calculations of structural dimensions structures are made using simplified methods, allowing a slight increase in the volume of construction to significantly reduce the cost of R & D activities. To reduce the cost of expensive materials (metal, cement), preference is given to structures based on earth, stone, wood and plastics.

In developing the project for construction work trying to sew needs for the construction of bridges and application of complex circuits overlap riverbeds. Construction is underway, as a rule, "on wheels", without the use of special production facilities and bases, using a series of construction machinery. Small hydro design is fully automated with remote control of all technological processes, the number of processing steps are trying to minimize.

In designs of buildings must cover toughness rapid-change elements of hydro-mechanical equipment and accessories for their repair by specialized companies. Repair of the main hydro-mechanical and power equipment (turbines and generators) is also produced by the replacement of individual modules and units.

Hydroelectric turbines for small hydro power plants produce many companies in the USA, Japan, Sweden, Austria, Switzerland, France, Finland, England and other countries [1,3,6]. Standardized equipment for small hydropower plants is available with a wide range of parameters: pressure – 1 ... 1000 m, spending up to 75 m^3 / s, power – 2 ... 15,000 kW turbine impeller diameters – 190 ... 3000 mm. Synchronous and asynchronous generators produce a voltage 380 ... 6300 V at 50 Hz and 60 Hz. For example, the main producer in the United States for small hydro power plants is a firm «Allis - Chalmers», producing standardized hydraulic units, including 12 models with 25 ... 1000 kW for heads up to 30 m. The range of the company "Excel Johnson Engineering" (UK) consists of units with capacity of 100 ... 1000 kW with a radial-axial, propeller and turbine bucket. Equipment, including valves, regulators, multipliers, control panels, etc. is available as a complete set, and individual nodes.

The Austrian company "West-Alpine" produces hydroelectric power of 10 kW ... 5000 with horizontal and vertical shaft. The company "Kessler" (Germany) produces a wide range of standardized equipment, which shows the so-called "tubular turbine" with the horizontal, inclined and vertical shaft. They are available in six varieties, sizes 15 (L_1 = 500 ... 3000 mm. for heads 1 ... 30 m with a flow rate of 1 ... 75 m^3 / sec and power of 50 ... 5000 kW). Pelton turbines of 10 kW are available ... 15,000 for heads 20 ... 1000 m.

In the Russian Federation Syzransky turbine-building plant with the participation of NGOs and the UKTI department "St. Petersburg Metal Works" developed conceptual basic types designs of parametric series of standardized hydrotherapy turbin for small hydro power plants. These turbines under the terms of s is divided into five groups and are designed to cost 1 ... 30 ^{3} m / s, pressure 5 ... 150 m and power – 160 ... 7000 kW. This series includes a propeller, radial-axial turbines in horizontal and vertical versions. The draft provides for maximum unification of turbines and typing of parts and components, modular and comprehensive post Application with maximum factory readiness. A project developed with microprocessor technology.

Currently, the Russian Federation, firms MIGA, INSET, RAND began the production of turbines for small hydro power plants with a pressure of 4 ... 20 m and 40 ... 180 m a distinctive feature of the proposed units is the use of the classical scheme of hydraulic turbines with adjustable guide vanes. Application in which electromechanical actuator with a microprocessor control and diagnosis. Instead of hydromechanical controls use electronic controls, which increases the reliability of the unit in the automatic mode.

Calculations performed Institute of "Hydroproject" [4] show that the maximum permissible investment in small hydro power plants vary greatly depending on the area of the location, investment in a replaceable thermal power plants, the fuel cost and duration of use of installed capacity. For areas in the zone of influence of power systems, the range of the maximum permissible specific capital investments in small hydro power plants account for 795 ... 1040 rubles / kW in the case of 50 % Displacement of power and 260 ... 500 rubles / kW in the absence of displacement capacity. These values allowed specific capital investments show that the construction of small hydro power plants will be quite effective in isolated areas.

It may be noted that in some cases a small plant can not be regarded as displacement, and can be regarded as redundant. The economic efficiency of such power plant is determined to save fuel.

Findings

To assess the economic feasibility of using the energy of small and medium-sized rivers in Ukraine should review existing materials and conserved small hydro meters. Necessary complex technical and economic study for the construction of new and reconstruction, restoration, abandoned small hydropower stations.

References

1. Karelin V.Y. Facilities and equipment of small hydro / V.Y. Karelin, V.V. Volshanik – M.; Energoatomizdat, 1986. – 186 p.
2. Malinin N.K. Economics of small hydropower abroad / N.K. Malinin, M.G. Basals / / Hydraulic engineering. – 1983. – № 12. – P. 34 - 37.
3. Malinin N.K. Small hydropower abroad / N.K. Malinin, M.G. Basals / / Hydraulic Engineering. – 1983. – № 6. – P. 49 - 52.
4. Mikhailov L.P. Small hydropower and its prospects / L.P. Mikhailov, A.S. Reznikovskii, B.N. Feldman // Hydraulic Engineering. – 1983. – №8 – P. 5-7.

5. Podgorinov A.L. Gidroenergetichne vikoristannya Malich richok / A.L. Podgorinov, L.S. Hilobochenko – K.: View of the Academy of Sciences USSR, 1959. – 195 p.
6. Feldman B.N. Status and trends of development of small hydro / B.N. Feldman, T.K. Markanova, M.I. Seregina / / Energy. the construction was abroad. – 1987. – № 3. – P. 14 - 17.