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Original Article

Research of potential and effectiveness of renewable energy application at mining enterprises of the Republic of Uzbekistan

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ABSTRACT

The theoretical analysis of renewable energy sources potential in the territory of mining enterprises as well as in the Republic of Uzbekistan is considered in the article. According to the results of the analysis, the theoretical and economic basis for the use of micro or small hydroelectric power plants as a source of renewable energy on the example of conditions of geotechnological mines of mining enterprises is presented. In particular, the article confirms that the use of micro and small hydroelectric power plants at mining and manufacturing enterprises is a cost-effective source, as evidenced by the histogram.

Keywords: Local sorption plant, micro and small hydropower plants, renewable energy source

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INTRODUCTION

Modern industrial development in Uzbekistan is characterized by an increase in energy consumption associated with the development of new mineral deposits located in remote and inaccessible areas. Centralized power supply in such regions is expensive and in some cases simply impossible.

Today, due to the increase in the production capacity of industrial, chemical, and mining enterprises, electricity consumption is increasing, which leads to an increase in electricity production and its cost.

MATERIALS AND METHODS

From the analyzed data, it was found that 0.3 m^3 of natural gas is used to generate 1 kW*h of electrical energy, and 2.5 kg of coal is also used in the conventional form. Besides, the process of electric energy production requires moving large volumes of raw materials through main networks, distribution among consumers, and organization of auxiliary production, which is very labor intensive.[1-4]

According to forecasts of leading scientists, natural resources of Uzbekistan, such as natural gas, oil, and coal, will be enough for at least 50–60 years, which requires to preserve these natural resources for future generations. If the above-mentioned natural resources are used for the electric power industry of the republic, that is, for production and needs in the electricity of the mining industry, it is quite probable that in the near future, the reserves of natural resources will run out.[2]

Increase of efficiency of mining enterprises due to reduction of expenses for energy supply is possible on the basis of wide use of renewable energy sources (RES), as regions of Uzbekistan possess significant reserves of renewable energy.

Wind generators, hydrogenerators, and hydroturbines, as well as solar radiation energy, biomass, heat energy of upper layers of the earth's crust, etc., are used as RES.

RES can be classified by type of energy:

- Mechanical energy (energy from wind and water flows)
- Heat and radiant energy (energy of solar radiation and heat of the earth)
- Chemical energy (energy contained in biomass).[3]

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There are separate assessments of renewable energy applications in the national electric power industry. In terms of potential size after solar energy, the second resource is water energy and the third resource is wind energy. The corresponding figure for biomass is 1.5 TWh/year. Below is the data characterizing the RES potential in the power generation segment [Table 1].

Climatic and geographical requirements of Uzbekistan also allow to use solar energy promptly for the purpose of extraction of electric energy and thermal energy on industrial scale. General possibility of solar energy of Uzbekistan is estimated at 50,973 million tons of oil equivalent (toe), that is, 99.7% with total full possibility of absolutely all researched to the present period in places of republic RES, industrial possibility – 176.8 million toe (98.6% with the total technological possibility of RES).

Annual energy of sunlight, entering the territory of the Republic of Uzbekistan, leads to a constant increase in energy intensity of hydrocarbon raw materials of the country.[1]

At present, only 0.6 million toe of solar energy, that is, 0.3% of the technical potential, which, in turn, is 0.34% of the gross potential, has been utilized.

Total potential of wind energetics of Uzbekistan, estimated on the basis of data of long-term weather observations (more than 10 years), made up 2.22 million US dollars/year. Technical potential of wind energetics in the republic is 0.43 million USD.[4]

Thus, the property of hydropower is characterized by the importance of 0.6–0.7; the front –0.3–0.7. The property of thermal also radiant RES does not exceed in any way 0.3–0.35. Even further, the property coefficient of clear emission used for photovoltaic conversion is 0.15–0.3. Comparing the energy of biofuel with the rest type of RES, the utilization factor will be equal to 0.3.[5]

The Potential of Renewable Energy in Uzbekistan

To date, the issue of RES in Uzbekistan is a priority both for economic development and for the welfare of the country as a whole. The reserves of coal, oil, and gas in Uzbekistan will be enough for many years and the key solution will be development and in the future the transition to alternative energy sources.

Table 1: Types and technical potentials of renewable energy sources

Resource name/indicator	Technical capacity (evaluation), TVt*h
Solar energy	2058
Small hydropower plants (up to 10 MW)	5.9
Wind energy	4.7
Biomass	1.5

Uzbekistan is rich in natural resources and is one of the leaders in the production of liquid hydrocarbons in Central Asia. Natural conditions allow the country to fully switch to RES.

To date, the country has great opportunities to introduce alternative energy sources into the use of urban and rural population. These are 360 sunny days/year, mountain rivers, and places where intensive winds develop, besides 60% of the country's population lives in rural areas where the energy infrastructure is poorly developed.

The main problem that prevents the use of solar and wind energy in the country is the high unit cost of their production compared to traditional energy sources. Low demand of potential consumers for alternative fuel, due to the availability of cheaper traditional energy sources, does not contribute to the development of production of equipment necessary for the development of alternative energy.

One of the main factors that hinder the development of "green" energy in the country is the lack of a competent legislative framework that would encourage the introduction of alternative energy sources. The second factor is the lack of interest on the part of local investors and large energy companies in financial support of projects aimed at implementing expensive technology introduction programs. In the near future, Uzbekistan will experience a shortage of energy resources, especially in liquid hydrocarbons, and by 2020, a significant increase of natural gas resources will be required to fulfill contractual obligations for its export supplies.

TECHNICAL POSSIBILITIES OF SOLAR ENERGY USE

There are 12 regions in the Republic of Uzbekistan, the difference in duration of sunshine for each region is from 2410 h to 3090 h/year, with fluctuations during the day of seasons, with duration of summer 11 h and winter 4 h.

In summer and winter in Uzbekistan, there is a difference of total solar radiation intake, in summer 27 MJ/m and in winter 7 MJ/m. In terms of number of sunny days per year, Uzbekistan exceeds South Spain, where solar energy is developed. One-third of the year can be considered as a cold season, the rest of the year has a high level of solar radiation.

Availability of solar energy potential predetermines the main directions of its use:

- Conversion of solar energy into low-potential heat and its use for heating needs
- Photoelectric and thermodynamic conversion of solar energy to generate electricity.

Today, in the world, solar energy is converted into electrical energy mainly by two methods – photovoltaic and thermodynamic. The photovoltaic method is far ahead of the thermodynamic one. Uzbekistan does not have any more or less large FS for power generation, but in the near future, it is planned to create an industrial development and energy saving program. The reason for not using FS is the high cost of helioelectric power plant construction, which exceeds the cost of thermal power plant by 1000 million kWh from 3 times to 10 times. To be economically competitive with fuel energy, the solar power industry has to meet the following criteria:

- The efficiency of solar power plants should be not <25% with the world average level of 16%
- Lifetime of the solar power plant should be 50 years
- Cost of installed kilowatt of peak capacity of solar power plant should not exceed 1500 dollars
- Production of semiconductor material for the solar power plant should not be more expensive than $ 25/kg
- It is necessary to provide round-the-clock production of electric energy by the solar power system.

Based on these criteria, it is possible to apply FS for the development of solar energy throughout the world, including Uzbekistan.

Technical Possibilities of Using Wind Energy

Uzbekistan has complex climatic processes due to its location. Considering this, wind energy is seasonal. In Fergana Valley, specific power of wind flow is 20.0 Wt/mv and in Navoi region 104.0 Wt/mv. Average value of wind flow of the republic is 84.0 Wt/mv. Distribution on territory of total duration of energy active (3 m/s and more) wind speeds is similar to distribution of average speeds. Maximum duration (6–8 thousand h/year) is typical for coasts and ridge zone of mountain ranges. In desert areas, the speed is observed during 3–4 thousand h, in the Fergana Valley – about 1500 h.

The greatest importance is typical for the Republic of Karakalpakstan. It is 0.92 million tons of oil equivalent per year. The smallest value is characteristic of the Ferghana Valley, it is –0.02 and 0.04 million tons of oil equivalent per year. Attempts to use wind power plants (WEU) of different capacity in different geographical locations of Uzbekistan (remote areas of Navoi and Bukhara regions, near the Farkhad hydroelectric power plant in Syrdarya region) in the past did not yield the expected results due to lack of serious scientific and technical substantiation of projects. Wind power plants of small capacity mass production are actively used in Uzbekistan, in the foothill zone from 3.0 and in the plain area up to 6.0 kW.

Wind energy potential assessment was carried out according to the data of observation of wind speeds by meteorological stations of Uzbekistan only at low altitude (10 m).

Technical Possibilities of Hydropower Use

In total in the Republic of Uzbekistan, there are 656 rivers. Their total area of spillway is about 83369 km. This area of spillway on capacity is equal to 12 231 MW/year. Existing in the world today equipment and technologies (technical potential) allows to use one-fourth of gross potential, that is, more than 7221 MW of installed capacity with annual output of 27 billion kWh.

Gross potential of small rivers, reservoirs, and large canals is relatively low. It is only 2% of the total primary energy resources and 13% of the total gross potential of the country's hydroenergy resources. It is not sufficiently sustainable as it depends on climatic conditions and the level of water availability of the year.

Besides, small rivers, reservoirs, and main canals have a certain potential for hydropower generation. The technical potential of small hydropower plants (HPPs) demonstrates the potential to introduce additional 14 small HPPs with capacity of 10–20 MW each and a total capacity of 87 MW in reservoirs.

Besides development of large and small HPPs, there is a potential for development of micro-HPPs in Uzbekistan (plants with capacity up to 2 kW).

Micro-HPPs are reliable, environmentally friendly, compact, and quickly recouped power sources for rural settlements, farms, small industries in remote mountainous and hard-to-reach areas where there are no power transmission lines nearby. They have high-energy characteristics and are designed to generate electricity without constructing a dam – using the energy of a gravity flow of water.

Micro-HPP with the capacity of 5 kW will allow to supply electric power to some small farms remote from settlements and centralized electric networks, and the installation with the capacity of more than 10 kW will allow to organize an enterprise for processing of agricultural products received.

Technical possibility of development of hydroresources of 27 more rivers on which it is possible to install 1101 micro-HPPs with total capacity of 304 MW and total output of 1764 GWh has been confirmed.

The developed potential of small power engineering is 31–37% of the technical potential. Economic potential of small power engineering development is higher and makes up 37–38%. It is connected with relatively low cost of electric power production on small rivers [Table 2].

Uzsuvenergo JV developed program on development of small hydroenergy sector for 2011–2015 with construction of 140 small HPPs, including the most profitable 20 HPPs with estimated cost of 260 million USD. Implementation of sectoral program will allow by the end of 2015 to increase generating capacities of the Ministry of Agriculture and Water Resources up to 613 MW and bring electricity generation at small HPPs up to 2.19 billion kWh.

RESULTS AND DISCUSSION

Among the most effective and promising directions of alternative energy development is the way of using own energy of water movement, or rather water flow, using electric generators.

At mining enterprises of Uzbekistan, in particular at Navoi Mining and Metallurgical Combine, there is a huge potential for application of micro and small HPPs. In particular, at geotechnological mines, there are local sorption units (LSU) [Figure 1].

Table 2: Classification of small-scale hydropower facilities by capacity

Name	Installed power	Expense	Impeller diameter
Micro-HPP	До 100 kW	<0.4 m3/s	<0.3 m
Mini-HPP	100–1000 kW	0.4–12.8 m3/s	0.3–0.8 m
Small HPPs	1–30 MW	>12.8 m3/s	>0.8 m

Source GOST 51238-98 hydropower small. HPP: Small hydropower plant

During the operation of LSU (local sorption unit) on the pipeline (8) installed between the tank (7) and the process card (9), a liquid with a volume of 85 l/s flows by gravity, which can be converted to usable energy using a micro HPP (hydroelectric power plant).

Useful transformation of liquid flow energy in LSU units allows to reduce the cost of electric energy during the operation of drainage and auxiliary units on geotechnological fields of the mine.

It should be noted that hydroelectric power plants can be installed practically on any watercourses: From small streams to the largest rivers. The capacity of their hydroelectric units changes accordingly. At present, the following classification is adopted: Stations with capacity of 100 kW – micro-HPP, from 100 about 1000 kW – mini-HPP, from 1000 about 10,000 kW – small HPP, and over 10,000 kW – large hydroelectric power plants. The design and construction principles of these classes of power plants may differ significantly.[2]

Micro-HPPs are distinguished by a great variety of design versions. They can be built, as well as more powerful plants, using a pressure pipeline or channel. Finally, micro-HPPs can be installed in a river stream without any hydraulic structures – free flow micro-HPPs.

The generator is the most important element of electrical equipment of autonomous electric installation. In addition to the main purpose, which is the generation of electrical energy, the generator must perform certain functions to stabilize or regulate the parameters that characterize its quality. Therefore,

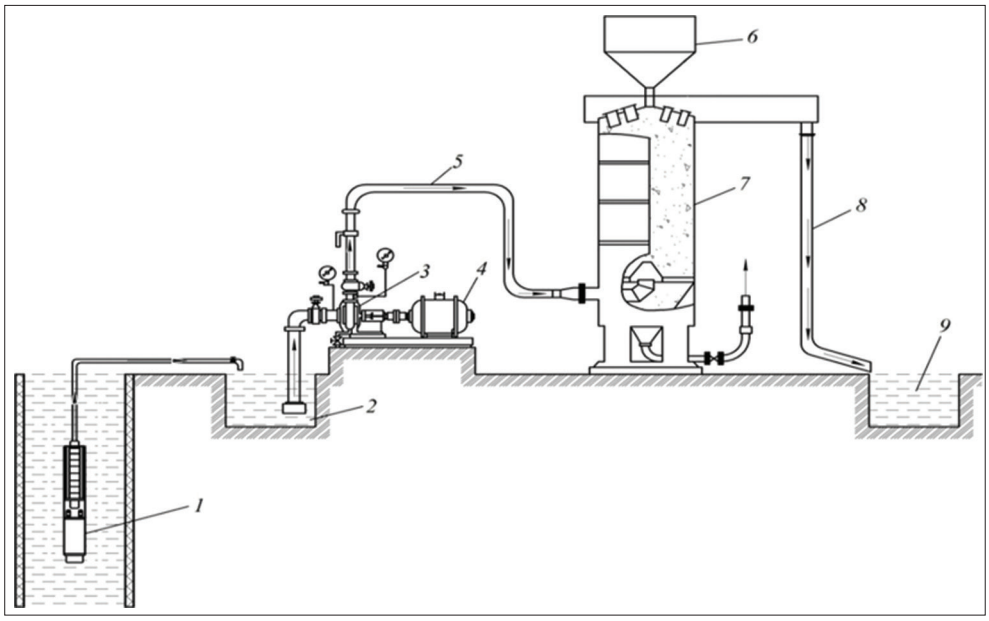

Figure 1: Core technological scheme of the local sorption plant. (1) Drain pipeline, (2) technological map (rich solution), (3) pump, (4) electric motor, (5) pipeline, (6) hopper, (7) tank, (8) pipeline, (9) technological map (poor solution)

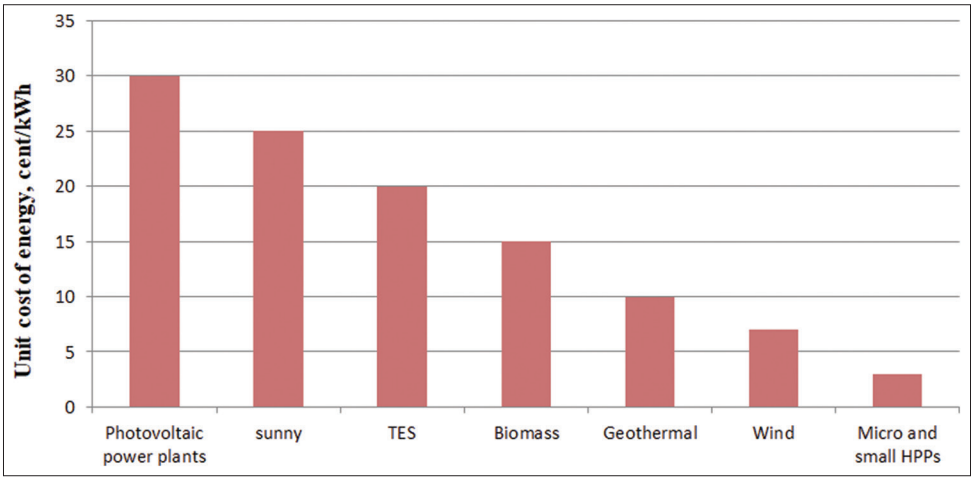

Figure 2: Histogram of specific cost of energy in obtaining them by different methods

one of the requirements to the generator of autonomous electric installation is controllability. The design of the generator should provide the possibility of its operation in the open air with a high degree of reliability for a long time.

Micro-HPP units mainly use alternators of synchronous or asynchronous types. The advantages of asynchronous generators are high reliability, small size, low cost, and ease of switching on for parallel operation. Their main disadvantages include the need for a capacitor bank for self-excitation and the relative complexity of regulation of the output voltage.

Figure 2 shows the specific cost of energy when it is obtained by various methods. From the histogram, it is observed that the use of micro and small HPPs allows to obtain electricity with the lowest cost.

From the above histograms, we can see that for the use of RES where the least consumption is required are micro and small HPPs.

At mining enterprises of Uzbekistan, in particular at enterprises of Navoi region, there is huge potential for application of micro and small HPPs. Production enterprises have technological schemes, where there are liquid flows through pipelines by gravity flow, which can be useful to convert into electrical energy with the help of electric generators.

CONCLUSION

Based on the analyzed data, the use of micro or small HPPs from RES as an additional source of electricity for mining enterprises is economically and environmentally efficient.

The conclusion is that from the above theoretical data, tables, and graphs when installing micro-hydropower plants or hydrogenerators in the flow of water from LSPs in geotechnological areas of mining enterprises will be provided with uninterrupted and reliable power supply.

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