

# Potential and Opportunities of the Use of Renewable Energy Sources in Uzbekistan

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**Abstract** — This article analyzes the possibilities of using renewable energy sources in Uzbekistan.

**Keywords** — Hydropower resources; Potential; motor torque; hydropower plants; hydropower plants;

## Hydropower resources.

There are more than 656 natural waterways in Uzbekistan, river's inflows with a total catchment area of 83,369 km<sup>2</sup> of different length and water content; as well as artificial waterways, water reservoirs of various capacity and available pressure, a lot of main and distributional irrigation channels, and a hydropower potential which could be used or is already used to produce electricity.

An estimated gross hydropower potential of rivers, is given in Table 1, according to a uniform methodology recommended by the International World Energy Conference.

**Table1.**

**Data on gross hydropower potential of rivers in Uzbekistan.**

Enlarged regions	Capacity, MW	Power, mln. kWh/year	% from total potential	Power density, kWh/km <sup>2</sup>
Chirchik - Angren basin	4079	35736,6	33,4	202,0
Ferghana Valley	2933	25660,0	24,0	166,0
Southwest region	4250	37104,9	34,8	20,7
Lower reaches of the Amu Darya	969	8500,0	7,8	5,64
Total for the country	12231	107001,5	100	

A program with the purpose to modernize existing HPP is developed and is implemented by company “Uzbekenergo” for the period 2016 - 2025 with an increase in the total installed capacity from 564.78 MW to 595.0 MW and average annual output of electricity from 2483.4 million kWh to 2844.78 million kWh and expected savings of natural gas – 930.0 million cubic meters in a year.

Technical energy potential of small HPP with calculated discharges into the downstream between 2.5 m<sup>3</sup>/s and 44.0 m<sup>3</sup>/s, with available pressure from 10.5 m to 145 m, as well as on the main irrigation channels with discharges between 50 m<sup>3</sup>/s and 158 m<sup>3</sup>/s for which there are possible drops from 2.0 m to 120 m, is shown in Table 2.

**Table 2.**

**Potential of small HPP.**

Location of possible HPP	Number of possible HPP	Total capacity, MW	The total average annual output of electricity, mln. kWh/year

Water reservoirs,	42	495,13	1331,016
including:			
Existing	23	210,85	439,1
Under construction	5	197,28	596,57
Prospective	14	87,0	229,346
Main irrigation channels	67	486,52	1893,3

Considering the prospects of hydropower resources in solving the escalating problems of optimization of operating modes of power system in the conditions of reduction of available capacity and shortage of maneuverable capacities, insufficiency of limits of allocated fuel (natural gas) on the task of SJSC “Uzbekenergo”- JSC “Hydroproject” has prepared “The scheme of using the hydropower potential of poorly explored natural watercourses of Uzbekistan for the period up to 2010”.

In accordance with the task, hydropower resources of 27 waterways of Uzbekistan have been investigated:

- in Tashkent region: rivers Chatkal, Akbulak, Koxsu, Pskem, Ugam, Akhangaran, Chirchik (downstream);
- in Jizzakh region: rivers Sanzar and Zaaminsu;
- in the Ferghana Valley: rivers Sokh, Shahimardan, Isfayramsay, Padshaata, Kasansay;
- in the Surkhandarya region: rivers Surkhandarya, Tupalngdarya, Kshtut, Sangardakdarya, Hodzhaipak (Halkadzhar);
- in Kashkadarya region: rivers Kashkadarya and Dzhindydarya, Akdarya (Aksu), Tanhizydarya, Kyzylarya (Yakkabagdarya), Katta-Uryadarya and Guzardarya, Kichik-Uryadarya.

For the specified natural watercourses, the concepts of energy application were developed and the placements of hydroelectric power plants were recommended, possible parameters of HPP were identified.

Hydropower indicators and operating modes of HPPs are established on the basis of processing the hydrological data on the actual average monthly discharge of water in the marked river stations over the entire period of observation, based on the data of the last 10-15 years.

As a result of investigation of natural waterways of Uzbekistan, the technical possibility of development in foreseeable prospect of hydropower resources in the amount of **2920.53 MW** of installed capacity and **9.965 billion kWh** of annually electricity generation has been confirmed, which is more than 1.5 times higher than water resources already developed.

Use of revealed hydropower potential envisages the construction of 122 hydropower plants, from which:

- 88 HPPs are planned in the unregulated sections of the rivers (installed capacity is 2352.65 MW, electricity generation is 7870.44 million kWh);
- 21 HPPs will be located at the existing, under construction and planned water reservoirs (installed capacity is 406.38 MW, electricity generation is 1147.66 million kWh);
- 13 HPPs will be located at the drops of irrigation channels (installed capacity is 161.5 MW, electricity generation is 947.7 million kWh).

Of all the scheduled hydropower plants on the waterways of the Republic, 16 are medium and large HPPs, 12 of them are located on the unregulated sections of the rivers. Total installed capacity of these HPPs is respectively 2050.3 MW and 1758.3 MW, average annual electricity generation is 6005.4 million kWh and 5198 million kWh.

#### **Small hydropower.**

For the development of small hydropower plants in Uzbekistan in 1995, a “Program of development of small hydropower in the Republic of Uzbekistan” was adopted, which was carried out in the system of Ministry of Agriculture and Water Management of the Republic. In 2003, it was put into operation the first hydroelectric power plant constructed under this program, Urgug HPPs (Samarkand region), with a capacity of 3 MW, and an annual generation of about 10 million kWh. In 2006, two power units of Tupolang HPPs (Surkhandarya region) were put into operation, each with a capacity of 15 MW. Two power units supplied to the load can generate electricity for a total of 63 million kWh per year. The construction cost of power units amounted to about \$ 24 million. The project was financed with funds from the sale of electricity generated by existing hydroelectric power plants of Ministry of Agriculture and Water Management.

In 2010 in Tashkent region with the use of credit resources of Eximbank of China, two small hydroelectric power plants were built at Akhangaran water reservoir and Andijan HPP-2 at Andijan water reservoir.

Total capacity of the two hydroelectric units installed on the Akhangaran HPPs is 21 MW. New energy facility at Akhangaran water reservoir has generated over 300 million kWh of electricity. Launch of these two units increased the potential of energy system of Uzbekistan Ministry of Agriculture and Water Management to 66.5 million kWh per year.

The capacity of Andijan HPP-2, is 50 MW. The average annual generation is 171.1 million kWh. The building of Andijan HPP-2 is equipped with two hydroelectric units with capacity of 25 MW, operating at a calculated pressure of 82 m and a calculated flow rate of 70.4 m<sup>3</sup> per second.

In 2011, Gissarak hydropower plant was put into operation in Kashkadarya region. The new plant operates mainly during the growing season of cereal crops and other crops, generating daily about one million kilowatt-hours of electricity.

In order to develop the hydropower in the republic, construction projects of several new small hydro power plants are also prepared.

Along with the modernization of hydroelectric power plants of SJSC "Uzbekenergo", association "Uzsuvenergo" is planning the construction of a new large and medium HPPs during 2016 – 2025 years with indicators presented in Table 3.

Table 3.

**The list of proposed projects for the construction of new HPPs in the medium term.**

No	Name of project	Installed capacity, MW	Cost of project, million dollars	Electricity generation, million kWh	The substitution of natural gas, million m <sup>3</sup>
	<b>Tashkent region</b>	817,6	848,8	2148,7	716,3
1	Pskem HPP on river Pskem	404	418,6	900	300
2	Mulalak HPP on river Pskem	240	236,9	580	193,3
3	Nizhnechatkal HPP on r. Chatkal	100	105,5	350	116,7
4	Akbulak HPP on r. Akbulak	60	62,8	260	86,7
5	Irgaylik HPP on river Ugam	13,6	25,0	58,7	19,6
	<b>Surkhandarya region</b>	120	148,9	450	150,0
6	Zarchob HPP on r.Tupalangdarya	90	115,6	350	116,7
7	Nilyu-2 HPP on r.Sangardakdarya	30	33,3	100	33,3
	<b>Total:</b>	937,6	997,7	2598,7	866,3

The construction of small hydropower plants(SHPP) in certain areas of the country is also envisaged for the period 2016-2025, which will provide an improvement in supplying power in the regions. Indicators of small hydroelectric power plants are given in Table 4.

Table 4.

**The list of proposed projects for the construction of small HPPs in the medium term.**

No	Name of project	Installed capacity, MW	Cost of project, million dollars	Electricity generation, million kWh
	<b>Tashkent region</b>			
1	SHPP at Tuyabuguz water reservoir	12,5	28,55	41,8
	<b>Namangan region</b>			

2	Cascade of SHPP on Fergana channel	10,8	34,97	68,4
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In accordance with the Decree of President of the Republic of Uzbekistan No.DP-4707 from 04.03.2015 “On the Program of actions to provide structural reforms, modernization and diversification of production in the years 2015-2019” the implementation of the following investment projects in the field of small hydropower are provided:

1. Construction of a new HPP-1 in Unitary Enterprise (UE) “Cascade of Tashkent HPPs” – with capacity of 4 MW in 2016-2018. The predictive cost of the project is 28.6 million US dollars.

2. Construction of “Kamolot” HPP with capacity of 8.0 MW in 2016-2017 and predicted cost of project of 12.1 million US dollars.

3. Modernization of Farkhad HPP, increasing the capacity of HPP to 13 MW in 2015-2016. The predictive cost of project is 131.0 million US dollars. Co-financed by the Islamic Development Bank (IDB).

4. Modernization of HPP-9 of “Cascade of Tashkent HPPs”, increasing the capacity of HPP to 5.3 MW (from 11.3 MW to 16.6 MW) in 2015-2017, with total cost of project equals to 40.0 million US dollars, co-financed by the IDB.

5. Modernization of HPP-3 of “Cascade of Kadirin HPPs”, increasing the capacity of HPP to 2.14 MW (from 13.2 MW to 15.34 MW) in 2015-2017, with total cost of project equals to 53.1 million US dollars, co-financed by the IDB.

6. Modernization of HPP-1 of UE “Cascade of Shakhrikhan HPPs”, increasing the capacity of HPP to 0.8 MW (from 1.5 MW to 2.3 MW) in 2016-2018, with total cost of project equals to 17.0 million US dollars.

7. Modernization of HPP-2 of UE “Cascade of Shakhrikhan HPPs”, increasing the capacity of HPP to 3.8 MW (from 3.25 MW to 7.05 MW) in 2015-2017, with total cost of project equals to 20.5 million US dollars, co-financed by the IDB.

8. Modernization of HPP-10 of UE “Cascade of Chirchik HPPs”, increasing the capacity of HPP to 5.0 MW (from 24 MW to 29 MW) in 2016-2018, with total cost of project equals to 41.4 million US dollars.

9. Modernization of HPP-2B of UE “Cascade of Samarkand HPPs”, increasing the capacity of HPP to 4.7 MW (from 21.9 MW to 26.6 MW) in 2016-2018, with total cost of project equals to 54.9 million US dollars.

#### The technical possibilities of using solar energy.

The long-term observations data on a network of actinometric stations in Uzbekistan indicate that the sunshine duration for different regions of the Republic ranges from 2,410 to 3,090 hours per year, with fluctuations during the day depending on the season and with a duration in the summer which is 11 hours and in the winter is 4 hours. Also, there is a difference of receipt of amounts of solar radiation, which is 27 MJ/m<sup>2</sup> per day in the summer and about 7MJ/m<sup>2</sup> in the winter.

Gross potential of solar energy, annually incoming into the whole territory of Uzbekistan, is significant and exceeds the energy potential of prospected hydrocarbon reserves of the country (Table 7).

**Table 7.**

#### Gross potential of solar energy over regions of Uzbekistan.

№	Region	million toe
1.	Andijan	129
2.	Bukhara	4747
3.	Fergana	215
4.	Jizzakh	2090
5.	Kashkadarya	3027
6.	Khorezm	542
7.	Namangan	241
8.	Navoi	14388
9.	Samarkand	1703
10.	Syrdarya	327
11.	Surkhandarya	2554
12.	Tashkent	1462
13.	Republic of Karakalpakstan	19548

Predictive estimation of technical potential of solar radiation energy in Uzbekistan is performed on the basis of forecast evaluation of gross potential and taking into account the stage of progress of conversion technologies in the world and Uzbekistan. Estimates have shown that the technical potential, calculated under the condition of using 1% of the territory when placing:

- solar installations with an efficiency of the solar collector 60%, is 133.0 million toe per year, or 0.26% of gross potential;
- solar photovoltaic modules with conversion efficiency 16%, is 42.46 million toe per year, or 0.08% of gross potential;
- solar-thermal power plants with a total installed capacity of 8000 MW, is 1.29 million toe per year, or 0.002% of the gross potential.

Thus, the total technical potential of solar energy at the present stage is 176.8 million toe, or only 0.34% of its gross potential. However, even this figure is 3 times more than the annual production of hydrocarbons in the country.

Availability of significant potential of solar energy determines the following main areas of its use.

### **Converting solar energy to low potential heat, and its use for heating.**

At the present time in Uzbekistan, a certain experience has been accumulated and the scientific-technical potential is created for using the solar energy in heating supply:

- standard of the Republic of Uzbekistan for solar hot water collectors and design standards of solar hot water supply systems are developed;

- a method is developed for calculation and optimization of thermal performance and structural parameters of the main element of solar heating systems which is flat hot-water collector, allowing to produce a comprehensive analysis of the degree of perfection of various designs of collectors and heat supply systems which are based on it;

- a design is developed and small-scale production of double-circuit solar water heating systems of year-round action is established, allowing to fully provide consumers with hot water during the warm and winter period of the year;

- a schematic diagram is designed and thermal engineering parameters of solar consoles are optimized for preheating raw water in fuel boilers of low power used in central heating systems of stand-alone or group of one- and multi-staged residential buildings, industrial enterprises, as well as small villages and neighborhoods, allowing to save fuel and energy resources up to 50%;

- exploratory research projects are conducted on development and creation of passive solar heating systems, adapted to the climatic conditions of the republic and providing up to 40-50% of heat demand of residential and public buildings during the winter period;

- certain investment projects are implemented, both by foreign and international grants and by enterprises' own funds.

However, the total area of installed solar collectors in the country is not significant and less than 40 thousand square meters. Solar collectors are installed only on a number of pilot facilities of motor transportation, medical and educational institutions of the republic, on the individual objects of the Ministry of defense of the republic, JSC "Uztransgaz", SJSTC "Uzbekistan Temir Yollari", Almalyk and Navoi Mining and Metallurgical Combines and on other facilities.

This is associated with low payback of solar collectors, firstly, because of their relatively high cost, and secondly, because of the relatively low rates of natural gas and accordingly to the thermal energy for consumers.

Payback of solar hot water collectors at such rates is more than 13 years, which does not stimulate people to implement them. The widespread implementation of solar collectors is associated with:

- further technological improvement of collectors by equipping them with batteries which can partially accumulate daily solar energy for use at night;
- reducing the cost of solar hot water collectors due to the expansion of volumes of domestic production;
- promoting the purchase of solar collectors by population due to lines of credit and other forms of support;
- increasing the tariffs for natural gas which is stimulating its savings.

Currently, for the daily living needs of the population, 16.5 billion cube meters of natural gas per year and 0.5 billion cubic meters of liquefied gas is spent. If we take into account that for the heating and hot water, supply is consumed up to 75% of this volume, and the rate of its replacement by solar collectors can technically be 50% per year, in this case the total savings of natural gas from the establishment and the widespread use of solar collectors for domestic use can be 37.5% of the total consumption of natural gas for domestic use, or 6.375 billion cube meters per year (5.17 million toe). Estimated cost of saved

natural gas is 1.4 billion USD per year (at a cost of \$220 per 1000 cube meters). Taking into account the existing differences between domestic and export prices, the additional disposable income of the gas industry will be more than 956 million USD per year.

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