

ENHANCING THE EFFICIENCY OF POWER SUPPLY TO THE CONSUMERS IN RURAL AND REMOTE AREAS BY PROVIDING THE ACCESS TO ENERGY RESOURCES AND SERVICES, AND BY IMPLEMENTING THE ADVANCED TECHNOLOGIES IN THE RENEWABLE ENERGY SECTOR IN UZBEKISTAN

INTRODUCTION.

Over the past twenty years, the Republic of Uzbekistan, as a result of diversification and modernization of the economy, has established itself as a developed country in the Central Asian region. The republic overcame difficulties of the transition period, the international financial-economic crisis and maintains dynamic GDP growth, which in the last six years is more than 8 percent. According to the estimates of international financial institutions, the same high rates of economic growth will persist in the near perspective.

President of the Republic of Uzbekistan, Islam Karimov, in his speech at the 6th meeting of the Asia Solar Energy Forum in Tashkent (in 2013) noted that country's needs in the electric energy will increase in the year 2030 by approximately twofold compared to this year's indicators and will exceed 105 billion kilowatt hours, taking into account the high advancing development rates in the manufacturing industry and the need to develop the agricultural sector. In this context, taking into account the need to improve the quality of population life, the need arises to analyze and find ways to reliable access to energy resources and services in rural areas, more than 80 percent of the country's vast territory. This would be consistent with a global UN initiative "Sustainable Energy for All", which provides achieving the following inter-linked objectives by 2030:

- Ensuring universal access to modern and environmental friendly energy resources;
- Doubling the rate of improvement in energy efficiency;
- Doubling the share of renewable energy in the global energy mix.

Providing universal access to modern energy services and using of renewable energy sources is determined not only by the main objectives of sustainable energy for all, but also by the need to ensure energy, food and environmental safety at the present stage of countries' development.

The problem is particularly acute for Uzbekistan in connection with the rapid growth of its population and the risks of water safety loss threats due to climate change and inefficient use of water resources.

By strategy for sustainable development of Uzbekistan, developed in the late of twentieth century, a staged solution of the following priority objectives is provided:

- modernization of oil-gas chemical complex of the country and its further development to ensure the fuel independence and to develop the energy sector;
- modernization and development of oil-gas transportation system for access to world energy resources market and for improving gas supply within the country including in rural areas;
- modernization of the agricultural sector, improvement condition of lands and efficiency of water resources using;
- diversification and modernization of electric power industry with more efficient use of fuel resources, electrical and thermal energy, sustainable electricity and heat supply, especially, in rural areas. In Fig. 1 energy balance of Uzbekistan is shown on primary energy resources.

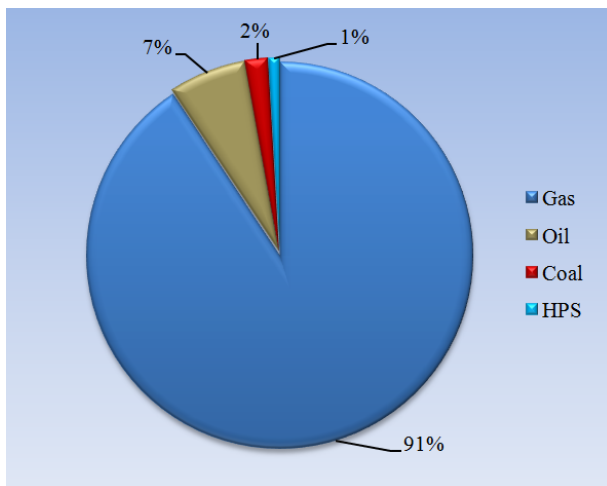


Figure 1. Energy balance of Uzbekistan.

It is seen from the figure that in the total energy balance of Uzbekistan, significant share fell to gas. Although the republic achieved energy independence in 1995, in terms of energy security criteria, it is energetically vulnerable.

Enhancing national energy security requires the adoption of appropriate actions in the following fields:

- diversification of consumed primary fuel-energy resources, increasing in the energy balance share of coal and hydro resources, exploring the use of oil shale;
- involvement in the energy balance of renewable energy;
- transition the sectors of the national economy to energy efficient and energy-saving technologies;
- release of low energy products with high share of intellectual labor in the cost of the product;
- training of highly qualified specialists for power industry.

In Uzbekistan, at the beginning of 2014 the number of rural settlements was more than 11 thousand [1]. There are 202 Rural settlements where reside up to 100 people, that is 1.8% of their total number. There are 1 thousand 90 rural settlements with a population from 101 to 300 people, in the country (9.9%), 1 thousand 344 with a population from 301 to 500 people (12.2%), 2 thousand 940 with population from 501 to 1 thousand people (26.7%). In 3 thousand 125 rural settlements of Uzbekistan (28.4%), there is a population between 1.001 thousand and 2 thousand people, in 1 thousand 295 settlements (11.8%) there are 2.001 thousand to 3 thousand people and in 597 rural settlements (5.4%), from 3.001 thousand to 4 thousand people. There are 222 rural settlements with a population from 4.001 thousand to 5 thousand people in Uzbekistan (2%) and 197 settlements with a population of 5.001 thousand or more people (1.8%).

Depending on the population size, the rural settlements are divided into:

- large – population is more than five thousand people;
- big – population is from three thousand to five thousand people;
- average – population is from one thousand to three thousand people;
- small – population is less than one thousand people.

In order to implement a wide range of actions for the further development of industrial and social infrastructure in rural areas, to improve the efficiency of the agricultural sector, to give a powerful new impetus to the deepening of economic reforms in agriculture, to accelerate the establishment of modern companies on deep processing of agricultural products, to ensure

employment growth in rural areas, especially for young people, to increase income and quality of life of rural residents, as well as in connection with the proclamation of 2009 year in the Republic of Uzbekistan - the Year of Rural Development and Improvement - the State program “Year of Rural Development” was adopted. In accordance with this program, in particular, it is provided that:

- improving the quality of life in rural areas on the basis of the further development of industrial and social infrastructure, provision of rural settlements with transport communications and clean drinking water, increasing coverage networks of telecommunications and postal services;
- creating favorable conditions for uninterrupted and guaranteed provision of the rural areas with required energy resources due to the reconstruction of existing and construction of new facilities of power and gas supply;
- consistent deepening of economic reforms in agriculture, further supporting of farming movement, strengthening its material and financial base, ensuring reliable protection of emerging new property relations in rural areas.

However, the problem of guaranteed provision of energy resources needed for rural areas still has not lost its acuity and thus leads to social tensions.

Therefore, the task of ensuring reliable access in rural and remote areas to energy resources and services through the development of appropriate mechanisms and implementation of advanced technologies in the field of renewable energy sources is highly relevant and acquires priority status.

PART 1. STATUS AND DEVELOPMENT TRENDS OF FUEL-ENERGY COMPLEX OF UZBEKISTAN.

Uzbekistan - the largest country in terms of population in Central Asia, it borders with Kazakhstan in the north and west, with Turkmenistan and Afghanistan in the south and in the east with Tajikistan and Kyrgyzstan. Currently, in the country reside over 31 million people, or about 45% of the total population of the Central-Asian region.

Annual GDP growth in recent years is 8-9%. More than 38% of the GDP goes to agriculture and for some percentage to the service sector, the share of industry is less than 25%.

Uzbekistan is a major producer and consumer of energy, one of the largest in the Asian continent. Primary energy production is more than 60 million tons of oil equivalents (TOE), consumption - 50.2 million TOE [2]. Uzbekistan ranks the 15th place among the largest consumers of energy resources in Asia. The main source of energy in Uzbekistan is natural gas, which is over 90% of the primary fuel-energy balance (FEB).

The raw material base of oil and gas.

At present Uzbekistan ranks second among the countries of Central Asia after Kazakhstan for oil reserves, and third after Turkmenistan for natural gas reserves. Proved oil reserves in the country are about 82 million tons, gas reserves - 1.85 trillion. m³.

Bowels of Uzbekistan have great potential to oil and gas. About 60% of the country is a potential for oil and gas. In five oil and gas regions, (Ustyurt, Bukhara-Khiva, Gissara, Surkhandarya, Fergana) 203 hydrocarbon deposits are discovered, including gas and gas condensate and oil – 99 % [3,4].

48% of discovered deposits are under development, 34% are prepared for development, and the rest is still being explored.

Oil fields are discovered in the Republic of Karakalpakstan and six administrative regions: Kashkadarya, Bukhara, Surkhandarya, Namangan, Andijan and Ferghana. About 75% of oil reserves are concentrated in the Kashkadarya region, primarily on the country's largest oil field - Kokdumalak (almost 70%).

The main free gas reserves are concentrated in the fields Shurtan, Zevardy, Kokdumalak, Alan and Adamtash. The high content of hydrogen sulfide in the gas is observed in the fields Urtaulak (5%), Dengizkul-Hauzak (4.25%), Kandym (1.89%), Akkum (1.92%).

Forecasted hydrocarbon resources (as of early 2007) are about 6 trillion m³ of natural gas, 850 million tons of oil and 380 million tons of gas condensate.

At the current volumes of mining, Uzbekistan is supplied with discovered natural gas reserves for 31 years and oil for 21 years, condensate - to 25 years. Search-exploration works are focused primarily on the north-west of the country – in Karakalpakstan, including on the Ustyurt plateau [3,4].

In 2005, in Uzbekistan, a strategic exploration program on oil and gas was developed for the period up to 2020, whose main objective is to ensure growth of hydrocarbon reserves (more than 1 trillion m³ of gas, about 70 million tons of oil and nearly 66 million tons of condensate). More than half (54%) of the growth of natural gas reserves are expected in the Ustyurt region, the main growth of oil reserves (about 44%) is in the Bukhara-Khiva region [3].

Mining and processing of oil and gas.

Under the conditions of population growth, continuing extensive development of the economy, increasing level of motorization, domestic consumption of oil and oil products increases, which against the background of roundedness of resource base leads to the need to increase imports of raw materials. In recent years, leadership of the country is actively involved in the solution of an inner problem: developing exploration, intensification of projects of oil mining at existing fields are starting, and new fields are developing, primarily through greater involvement of foreign companies with advanced technology and sufficient financial resources.

The total volume of natural gas production reached in 2010-2014 the value of 62.7 billion m³. Over the past 10 years commercial gas production has increased by 21.7%. Under the conditions of some reduction in domestic consumption of gas, exports have increased.

About 80% of the produced gas is consumed internally. On gas consumption per capita, Uzbekistan is slightly behind Russia (1.6 thousand m³ per person per year), exceeding the global average more than 3.5 times on this indicator.

Oil refining.

Until 1995 Fergana and Altiarik oil refineries mostly processed raw materials supplied by pipeline from Western Siberia. At present, loadings of oil refineries are carried out due to production in territory of Uzbekistan and import from Kazakhstan. Bukhara oil refinery is intended mainly for the production of high-octane gasoline based on gas condensate field Kokdumalak.

Most of the Uzbek gas has high sulfur content, so it is reprocessed at the Mubarek gas processing plant in Kashkadarya region, with a capacity of more than 29 billion m³ per year.

In 2003 – 2004, as a result of technological re-equipment of the Fergana oil refinery, there was an increase in the depth of oil refining. It allowed to increase production of petroleum by more

than a third and to increase exports of gasoline, jet fuel and diesel fuel by more than 1 million tons per year.

Nowadays Fergana oil refinery is one of the leading enterprises for the production of fuels and lubricants in the Central Asian region. There are 35 technological operational units in the company, which allow producing almost all range of existing oil refining petroleum products.

In summer 2005, the Uzbek-Russian joint venture “Dzharkurganeftepererabotka” has commissioned in Uzbekistan an oil refinery worth \$ 7 million and with a design capacity of 130 thousand tons of crude oil per year. Capacities of the enterprise are focused on the processing of “heavy” oil with high paraffin content. Each year, at the plant, is produced 50 thousand tones of petroleum bitumen and diesel fuel, and other petroleum products.

Gas processing.

Gas processing in Uzbekistan is carried out at three plants - Mubarek Gas Processing Plant (GPP) (more than 29 billion m³ per year), “Shurtaneftegaz” (12.0 billion m³ per year) and Shurtan Gas Chemical Complex (4.5 billion m³ per year).

Shurtan Gas Chemical Complex annually produces 125 thousand tons of polyethylene granules, 130 thousand tons of liquefied natural gas and gas condensate, and 4.2 billion m³ of gas and 4 thousand tons of sulfur. The technology, used in the production, is designed to produce about 150 kinds of polyethylene of high, medium and line low pressure, much of which is exported.

Company “Uzbekneftegaz” plans to increase production of liquefied natural gas to 615 thousand tons. Increasing of liquefied natural gas production will take place mainly on the basis of the Mubarek gas processing plant and “Shurtaneftegaz”.

Uzbekistan has a well developed and sufficiently powerful system of trunk pipelines and pipeline branches allowing transporting the natural gas to Republican and external customers.

The total length of gas pipelines in Uzbekistan exceeds 13 thousand km. The capacity of the gas transportation system of Uzbekistan is 55 billion m³ per year, which allows pumping the transit from Turkmenistan and supplying of Uzbek gas for export.

In 2005, development of a program of gas pipelines is launched, covering the period up to 2020. The program is aimed at increasing natural gas exports to 16 billion m³.

The annually extracted natural gas consumed: *for own needs of oil and gas industry, is 19.2%, in the electric power industry it's 19.6%, in other industries (chemicals, metallurgy, etc.) it's 15.2%, by population, 23.6%, to export 20.2%, losses, 2.2%.*

Table 1 summarizes data on providing the population with gas across the regions.

Table 1. Provision of the population with natural gas.

	Level of provision (%)		
	2000 y.	2005 y.	2010 y.
Republic of Uzbekistan	76.1	80.0	83.7
-rural population	65.9	71.5	77.7
Republic of Karakalpakstan	90.7	92.4	94.0
Andijan region	64.6	70.0	74.0
Bukhara region	79.6	82.9	95.0
Jizzakh region	72.0	75.3	75.3
Kashkadarya region	62.6	72.8	68.8
Navoi region	74.5	79.9	80.4

Namangan region	57.0	80.8	84.8
Samarkand region	85.6	87.6	84.4
Surkhandarya region	55.0	62.3	60.4
Syrdarya region	86.3	84.3	77.3
Tashkent region	81.9	87.6	83.4
Ferghana region	86.0	79.6	80.6
Khorezm region	90.5	96.6	95.0
Tashkent city	97.3	97.5	97.5

Source: data from State Committee on Statistics of Republic of Uzbekistan.

In Uzbekistan, there are more than 11.0 thousand rural settlements (RS), from which over 600 are not supplied with gas on the technical and economic conditions. Some of the RS are located in remote, hard-to-reach, mountain, semiarid regions. All RS have schools, rural medical centers and hospitals, the base stations of mobile communication facilities who need a stable, sustainable electricity, heat, water for drinking and irrigation purposes.

During the heating season, in some regions, there is a significant drop in gas pressure and accordingly a deterioration of heat supply of population and certain industries (Samarkand, Kashkadarya, Ferghana, Namangan, Andijan regions, Republic of Karakalpakstan).

Oil consumption, according to estimates, will increase by 2020 – up to 12.3 million tons and in 2030 will be about 16 million tons [4]. Per capita consumption of oil will increase from 0.31 tons per person in 2006 to 0.47 tons in 2030. In order to meet the country's needs in petroleum products, import of raw materials will be required into the territory of Uzbekistan in the amount of 6.7 million tons in 2020 and 8.8 million tons in 2030.

According to the forecast, the natural gas annual production in Uzbekistan will increase, mainly due to the full-scale development of gas fields in Ustyurt region.

Coal industry.

Explored reserves of coal is 1832.8 million tons, including brown coal - 1786.5 million tons, stone coal - 46.3 million tons. Projected resources are 3.5 billion tons. Large reserves of coal are in Surkhandarya and Kashkadarya regions. Coal production in Uzbekistan carried out by JSC “Uzbekugol”, JSC “Shargunkumir” and LTD “Apartak”. On the coal mine “Angren” coal mining is conducted by open pit method. In addition, JSC “Yerostigaz” produces gas from brown coal by underground gasification.

Station of JSC “Yerostigaz” is a unique industrial facility that hasn’t analogues in the world. The main purpose of the company is the underground processing of brown coal in power gas followed by its use in Angren combined heat and power station. In 2012 coal production was 3.9 million [4].

Considering the importance of increasing the share of coal in the energy balance of the country, the decision of the government on a Program of development of the coal industry up to 2019 was approved, according to which implementation of new advanced technologies, improving production processes, the implementation of a number of investment projects aimed at modernization, technological upgrading and expansion of existing facilities is planned.

In order to increase the level of brown coal mining and the need for substantial upgrading of LTD “Apartak”, the construction of a plant is envisaged for the synthesis of alternative diesel fuel from brown coal on the mine “Apartak” using innovative technology with capacity of 2.2 million

tons of brown coal per year, or receive 700 thousand tons of diesel fuel, as well as a project is preparing to build facility for production of aluminous cement from secondary kaolin and et al. [5].

Combustible slates.

Probable reserves of combustible slates in Uzbekistan are about 47 billion tons. The output of the diesel fraction from tar slate deposit “Sangruntau” with 357 million tons of reserves (C1 + C2) reaches about 30%.

The project with an estimated cost of \$ 600 million is planned to be funded by “Uzbekneftegaz”’s own funds, credit from Fund for Reconstruction and Development of Uzbekistan and foreign credits [6].

According to the plan, at the first stage on the basis of mine “Sangruntau” in Navoi region will be built starting complex for processing 2 million tons of combustible slates per year. In the future, the power plant is expected to reach production of ore slate to 8 million tons and production of oil to 1 million tons annually.

Electrical and heat power system.

At the beginning of 2013, in the power system of Uzbekistan, there are 45 power plants with total capacity of more than 12.4 thousand MW [7]. The enterprises of the State Joint Stock Company (SJSC) “Uzbekenergo” in 2013 produced 53.2 billion KWh of electricity and released to consumers 8.0 million Gcal of heat energy. Experts predict that by 2030, the demand for electricity in the country will almost double and reach more than 105 billion kWh.

In Figure 2 the structure of consumption of fuel in power plants of SJSC “Uzbekenergo” and the structure of energy consumption by sectors of the economy are shown [5, 8]. It is seen that the main fuel for power plants is a gas that creates certain problems and raises the issue of diversifying the fuel base of the company. The main consumers of electrical energy are industry, housing and communal services and agriculture.

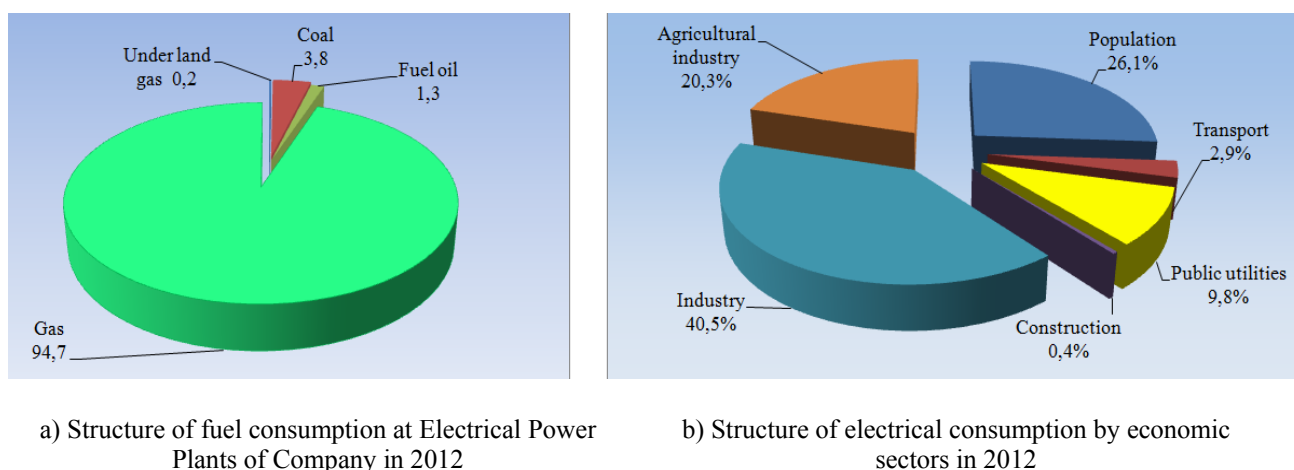


Figure 2. Structural indicators of SJSC “Uzbekenergo”.

Investment activity of SJSC “Uzbekenergo” is defined by decrees of the President of Uzbekistan “On the Program of industrial development of Uzbekistan for 2011-2015” (PP-1442 from 15.12.2010) and “On the investment program of the Republic of Uzbekistan for 2013” (PP-1855 from 21.11.2012), according to which the main directions of development of the industry until 2015, involving the implementation of 48 investment projects envisaging:

- implementation of modern technologies of combined production of electricity and heat based on the combined cycle power plants (CCPP);
- increasing the share of solid fuels and hydropower in the fuel and energy balance with the reconstruction of existing coal-fired power plants, modernization and reconstruction of existing hydro power plants;
- construction of interconnection transmission lines and substations for 220-500 kV and deep feeding closed substations for 110 kV for the transmission of electric power and energy to scarce power supply units;
- modernization of the accounting system of electricity consumption by equipping consumers of domestic sector with modern electronic meters and the organization of the automated system of electricity metering.

The electric power industry of Uzbekistan is based on thermal power stations (ThPS). The four largest thermal power stations have an installed capacity of over 1,000 MW: Syrdarya ThPS - 3,000 MW, Novo-Angren ThPS - 2100 MW, Tashkent ThPS - 1860 MW and Navoi ThPS - 1250 MW. On Talimarjan ThPS is in operation the unit 1 with capacity 800 MW. In the power system of the republic along with ThPS there are functioning HEGP (heat -electric generation plant), working on cogeneration cycle. There is Ferghana HEGP (installed electric capacity - 305 MW, thermal capacity - 1421 Gcal/h), Mubarek HEGP (installed electric capacity - 60 MW, thermal capacity - 376 Gcal/h) and Tashkent HEGP (installed electric capacity - 30 MW, thermal capacity - 178 Gcal/h).

In Tashkent HEGP in the framework of the project on implementation of gas turbine technology was built gas turbine unit with capacity of 27.15 MW.

In Syrdarya and Talimarjan ThPS turboexpander-generator units with capacity 20 MW are implemented [9].

In 2012, the transfer works was completed on units № 1-5 Novo-Angren ThPS with year-round burning of coal. Project was launched to build on the Angren ThPS power unit with capacity 130-150 MW district heating extraction to burn high-ash coal. All of this allows to successfully meet the challenges associated with an increase in the fuel and energy balance in the share of solid fuels.

Works are underway on the construction of two combined-cycle units of capacity of 450 MW at Talimarjan ThPS and combined cycle gas turbine with capacity of 370 MW at Tashkent ThPS.

The Asian Development Bank is considering the issue of co-financing the project of construction of gas-steam installation (GSI) with capacity of 230-250 MW at Takhiatash HEGP and with JICA(Japan) - the second GSI with capacity 450 MW at Navoi ThPP [10,11].

In the medium term, the construction of a new thermal power station in Surkhandarya with 300 MW is assumed based on coals of Shargun and Baisun deposits to cover load growth in the region and increase electricity exports to the south [12].

The realization of another major project, on which preparatory works have begun, is the construction of a new thermal power station with a total capacity of 900 MW in Turakurgan district of Namangan region - will allow to improve the reliability in power supply of industrial enterprises, social facilities and the population not only in Namangan, but also other areas of the Fergana Valley [12].

Hydro Power.

Hydropower of Uzbekistan consists of 29 hydroelectric power plants (HPP) as part of SJSC “Uzbekenergo” united in 5 cascade HPPs and hydroelectric power plant in the structure of a specialized association (SA) “Uzsuvenergo” of the ministry of agriculture and a water management (MAWM) of Uzbekistan.

Cascade of Urta-Chirchik HPPs.

The installed capacity is 905.5 MW, available capacity at the end of the year is 905.5 MW. There are 3 HPP as part of the cascade wherein 10 hydroelectric units are installed.

Cascade of Chirchik HPPs.

The installed capacity is 190.7 MW, available capacity at the end of the year is 173.1 MW. There are 3 HPP as part of the cascade wherein 10 hydroelectric units are installed.

Cascade of Kadirin HPPs.

The installed capacity is 44.6 MW, available capacity at the end of the year is 44.6 MW. There are 4 HPP as part of the cascade wherein 8 hydroelectric units are installed.

Cascade of Tashkent HPPs with branches.

The installed capacity is 97 MW, available capacity at the end of the year is 44.6 MW. As part of the cascade are included:

- 4 stations of Tashkent HPPs cascade wherein 10 hydroelectric units are installed with total capacity of 29 MW (available capacity is 21.5 MW);

- 4 stations of Samarkand HPPs cascade wherein 9 hydroelectric units are installed with total capacity of 40.1 MW (available capacity is 28.5 MW);

- 4 stations of Shahrikhan HPPs cascade wherein 6 hydroelectric units are installed with total capacity of 27.9 MW (available capacity is 22.4 MW).

Cascade of Nizhne-Bozsu HPPs.

The installed capacity is 50.9 MW, available capacity at the end of the year is 50.9 MW. There are 5 HPP as part of the cascade wherein 10 hydroelectric units are installed.

Farkhad HPP.

The installed capacity is 126.0 MW, available capacity at the end of the year is 118.7 MW. 4 hydroelectric units are installed.

In the HPP cascades, due to prolonged operation, all hydro turbines and hydro power equipments had worked out its normative resource, physically and morally worn out. As a result, the amount of usable hours of a number of hydroelectric power plants is not high. Activities are provided on renewal and modernization of hydroelectric equipment.

The largest hydroelectric power plants, Charvak HPP with capacity of 600 MW and Hodzhikent HPP with capacity of 165 MW, have water reservoirs that allows to operate in the mode of adjustable power, which is very important for the electric power system of the republic due to the fact that the main volume of electricity is generated by thermal power plants, and to meet the peaks of electric load partially some TPP are used, which are operating in out of projected modes.

Besides, the purchasing of peak generation capacity is carried out from neighboring electric power systems of Central Asian countries for foreign currency. The rest of the HPPs operate on the watercourse in the basic mode.

SJSC “Uzbekenergo” is implementing investment projects aimed at modernization of hydrogenerators in Charvak HPP with replacement of impellers and respectively with a capacity increase to 45 MW, HPP-14 cascade of Nizhne-Bozsu HPPs with a capacity increase to 4.3 MW and Farkhad HPP with capacity increase to 13 MW [7].

The issues are being worked out with the Islamic Development Bank on joint implementation of modernization projects of hydroelectric power plants at cascades of Tashkent, Kadyrin, Chirchik HPPs with a capacity increase to more than 70.0 MW [13].

In 1995, the Government of the Republic approved the **Program of development of small hydropower up to 2010** costing about \$250 million, in which frameworks in the republic was planned to construct 15 hydro power plants with total capacity of 423 MW and electricity generation - 1.36 billion kWh per year. By now it has been put into operation five plants with a total capacity of around 110 MW, including Urgut HPP - 1.5 MW, Tupolang HPP - 30 MW, Akhangaran HPP - 21 MW, Andijan-2 HPP - 50 MW. The total capacity of nine hydro power plants of Ministry of agriculture and water management has reached the 439 MW.

In 2011 SA “Uzsuvenergo” formulated the **Program of development of small hydropower for 2011-2015**, which envisages the implementation of nine projects costing \$260 million. Within the Program was scheduled to carry out construction of seven new and reconstruction of two existing small hydro power stations in Tashkent and Surkhandarya regions. Implementation of the Program will allow increasing the generating capacities to 613 MW until the end of 2015, which would allow increasing the electricity generation in small hydropower plants from 1,115 billion kWh to 2.19 billion kWh. At the construction of new capacities, it is expected to achieve savings of natural gas in the amount of 685 million cubic meters annually [11].

Electricity Grid Lines.

The total length of electric grids with voltage 0.4-500 kV is more than 243 thousand kilometers, 1673 substations units with voltage 35 kV and higher and with a total installed transformer capacity of more than 40 million kVA and 67574 transformer points to 6-10 kV with total capacity of about 22.5 million kVA are in operation.

The overall level of losses in the electric power in Uzbekistan exceeds 30% [14]. Technical losses in electric networks are about 13%, 25% of which - in the national areas of the regional main networks to 500 kV and 75% - in distribution networks. Uzbekistan encounters the problem of power cuts in East energy system (Fergana Valley), as well as in Samarkand-Bukhara and Surkhandarya energy systems due to the lack of their own generating facilities. In autumn and winter power cuts are significant and occur regularly due to the deficiency of generating capacities in these regions.

Transportation of electric energy from generating sources to the distribution companies is performed by unitary enterprise “Uzelektroset” through main electric networks with voltage of 110-500 kV, and length of about 10.0 thousand kilometers. Transformers are installed with total capacity of more than 20 million kVA in 76 substations of enterprise.

The implementation of electricity to consumers is carried out by enterprises of territorial electric networks through power transmission lines with voltage of 0.4-110 kV and length of 226.9 thousand kilometers.

5 projects are being implemented with putting transformer capacities of 595 MVA and power grid lines with length of 283.4 kilometers in the 220 kV electric networks.

In the distribution networks, 0.4-6-10-35kV processes are being implemented for modernization and upgrade of 23.9 thousand kilometers of transmission lines, more than 3.6 thousand 6-10 kV transformer units and more than 40 substations of 35 kV, as well as construction of 1.2 thousand kilometers of power grid lines, 400 transformer units of 6-10 kV and 15 substations of 35 kV.

In the development of the main electric networks of 500 kV, projects are implemented on construction of high voltage transmission lines 500 kV “Talimarjan TPP – SS(substation) Sogdiana” stretching 218 kilometers with open switchgear 500 kV in plant, high voltage transmission lines 500 kV “Sirdarya TPP - Novo-Angren TPP” stretching 130 kilometers for providing stable operation of power grid of the Central part of electric power system, improving the reliability of power supply to consumers, providing power supply for the new consumers and reducing losses during transportation of electricity [11].

SJSC “Uzbekenergo”, until 2018, plans to build a high-voltage power transmission line 500 kV “Ellikala-Zarafshan” with a total cost of \$190 million. The line stretching 336 kilometers is designed to provide a stable electric energy flow from the Khorezm region in the north-west to the Navoi region in the central part of the country.

Qualitative evaluation of the parallel operation advantages of the Central Asian Power System (CAPS).

The regional infrastructure of CAPS has been built as an integrated system, using distributed resources optimally. The representatives of the energy sectors of the countries of Central Asia agree that from a technical point of view, it is not hard to restore the parallel operation of the system. Parallel operation provides advantages and opportunities for all participants, in particular [15]:

1. Optimal use of primary resources, promoting:
 - reducing the consumption volumes of natural gas/coal;
 - preventing seasonal water releases and therefore optimally using the local excess electricity.
2. The parallel operation of power systems provides the ability for an optimization of generating capacities and improving the efficiency of thermal power generation. Regards the perspective, rational regional network promotes the development of the use of renewable energy sources (RES). The use of RES will allow increasing export of excess volume of electricity.
3. A further advantage of parallel operation is the optimization of the load curve in the CAPS. It should be noted that there are 2 different time zones (4 GMT and 5 GMT) in the region. The graphs demonstrate that daily peak loads fall on the different hours in the countries of CAPS.

Thus, disunited work of national energy systems in Central Asian countries leads to interruptions in the delivery of electricity to consumers, primarily to the residents of rural and remote villages, and does not allow to take advantage of diversified fuel and power structure of the region as a whole.

PART 2. POTENTIAL AND OPPORTUNITIES OF THE USE OF RENEWABLE ENERGY SOURCES IN UZBEKISTAN

Hydropower resources.

There are more than 656 natural waterways in Uzbekistan, river’s inflows with a total catchment area of 83,369 km² 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 3, according to a uniform methodology recommended by the International World Energy Conference.

Table 3. Data on gross hydropower potential of rivers in Uzbekistan.

Enlarged regions	Capacity, MW	Power, mln. kWh/year	% from total potential	Power density, kWh/km ²
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 m³/s and 44.0 m³/s, with available pressure from 10.5 m to 145 m, as well as on the main irrigation channels with discharges between 50 m³/s and 158 m³/s for which there are possible drops from 2.0 m to 120 m, is shown in Table 4.

Table 4. 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, including:	42	495,13	1331,016
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, Koksus, 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, Tupalangdarya, Kshut, Sangardakdarya, Hodzhaipak (Halkadzhar);
- in Kashkadarya region: rivers Kashkadarya and Dzhindydarya, Akdarya (Aksu), Tanhizydarya, Kyzylidarya (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 m³ 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 5.

Table 5. The list of proposed projects for the construction of new HPPs in the medium term.

№	Name of project	Installed capacity, MW	Cost of project, million dollars	Electricity generation, million kWh	The substitution of natural gas, million m ³
	Tashkent region	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
	Surkhandarya region	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
	Total:	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 6.

Table 6. The list of proposed projects for the construction of small HPPs in the medium term.

№	Name of project	Installed capacity, MW	Cost of project, million dollars	Electricity generation, million kWh
	Tashkent region			
1	SHPP at Tuyabuguz water reservoir	12,5	28,55	41,8
	Namangan region			
2	Cascade of SHPP on Fergana channel	10,8	34,97	68,4

3	Kamchik SHPP	18,0	45,30	58,9
	Samarkand region			
4	Shaudar SHPP on Dargom channel	7,2	25,60	37,6
5	SHPP 135 on Dargom channel	6,4	22,40	30,8
6	SHPP 102 on Dargom channel	5,2	22,30	27,5
	Surkhandarya region			
7	Zarchob SHPP-1	23,0	50,60	67,1
8	Zarchob SHPP-2	23,0	42,17	67,1
9	Zarchob SHPP-3	23,0	46,00	67,1
	Syrdarya region			
10	SHPP at Sardobin water reservoir	15,0	29,58	52,0
	Bukhara region			
11	SHPP at Sichankul fault	24,2	53,24	84,7
	Total:	162,9	400,71	577,4

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/m² per day in the summer and about 7MJ/m² 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
	Total:	50973

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.

Photoelectric and thermodynamic conversion of solar energy to electricity.

Currently in the world, solar energy is converted into electrical energy by two main methods: photovoltaic and thermodynamic.

Most of medium and large photovoltaic (PV) systems are currently embedded into the grid.

In order to compete economically with fossil energy, solar energy is necessary to achieve the following parameters:

- the efficiency of solar power plants must be at least 25% at today's average level of 16%;
- the service life of solar power plants should be 50 years (currently, before the reconstruction - 20-25 years);
- the cost per installed kilowatt peak power of solar power plant should not exceed 1500-2000 dollars (currently 6000-8000 dollars);
- production of semiconductor material for SPP should not be more expensive than \$25/kg;
- materials and technology of production of solar cells and modules have to be clean and safe.

President of the Republic of Uzbekistan on March 1, 2013 signed a decree (PD-4512) **“On activities for further development of alternative energy sources”**, which essentially defined the strategy of development of renewable energy in the republic.

In the decree the following objectives are marked:

holding the research and development at a higher technical and scientific level, taking into account the world experience of practical application of individual decisions on using alternative energy sources in Uzbekistan, as well as the organization of the domestic production of advanced equipment and technologies for this sector.

In the decree the activities defined and required to solve the tasks are:

- development and implementation of experimental and pilot projects on the use of solar and biogas energies with the involvement of the Asian Development Bank and other international financial institutions;
- to launch the activities on stimulating manufacturers and consumers of solar and biogas energies, and providing them tax and custom privileges and preferences;
- implementation of advanced technologies on renewable energy sources in the republic and throughout Central Asia;
- establishment in the free industrial economic zone of Navoi, a joint venture for the production of photovoltaic panels with capacity of 100 MW;
- realization of the construction project of solar photovoltaic power plant of 100 MW in the Samarkand region.

On the order of the the President of Uzbekistan (PO-1929 from 01.03.2013) in the republic the International Institute of Solar Energy was established.

The purpose in creating the institute is:

the fulfillment of scientific and experimental research in the field of solar energy use through enhanced international cooperation, to develop proposals for the practical application of the potential of solar energy in various sectors of economy of the republic through the implementation of advanced and economic effective technologies and equipment.

The main tasks and objectives of the Institute are:

- the implementation of high-technological developments in the field of industrial application of solar energy;
- practical application of the potential of solar energy in various sectors of economy and social sphere on the basis of advanced and economic effective technologies;

- the fulfillment of applied research related to the application of solar energy in various sectors of economy, including technologies for the synthesis of special materials and heat treatment.

According to the Memorandum of Understanding signed between the Government of the Republic of Uzbekistan and the Asian Development Bank (ADB) in March 2011, works are conducted on the realization of the Project PATA 8008 “Development of solar energy”.

Within the project, the following works were performed:

- a road map is being made to develop the use of solar energy;
- a pre-feasibility study (PFS) is developed for 6 solar power plants in various regions of the republic;

- Ministry of Economy of the Republic of Uzbekistan, the Ministry of Finance of the Republic of Uzbekistan, the Asian Development Bank, the Fund for Reconstruction and Development of Uzbekistan work on SJSC “Uzbekenergo” a project is drafted on solar photovoltaic power plant with capacity of 100 MW in Samarkand region;

- works are carried out on the collection of data on the solar radiation in the six regions of the republic.

A technical assistance project of ADB SCDTA 7846 is being implemented which aimed at modernizing the Big solar furnace (BSP) of the Institute of Material Science and equipping the certification laboratory of the International Institute of Solar Energy by measuring devices.

In accordance with the Decree of the President of the Republic of Uzbekistan № PD-2183 from 04.06.2014 “On activities to implement the investment project “Construction of a solar photovoltaic power plant with capacity of 100 MW in the Samarkand region””, works have started on the project.

It was planned in 2014, with the participation of the largest Chinese companies to establish on the territory of free industrial-economic zone “Navoi”, the production of photovoltaic panels with capacity of 50 MW, and in the special industrial zone “Jizzakh” to establish the enterprise for the production of solar thermal collectors with an annual capacity of 50 thousand units.

The construction of several more large-scale solar power plants based on new high-performance technologies is assumed. For this purpose, the most modern measuring stations are posted in 6 regions of Uzbekistan.

In cooperation with South Korean company “Neoplanta” in Navoi a plant is put into operation for the production of technical silicon with capacity of 12 thousand tons per year. On the territory of special industrial zone “Angren” with participation of the South Korean company “Shindong Enerkom”, the construction of a second plant is completed for the production of silicon with a capacity of 5000 tons per year. In the future, these products can become a source of raw materials for manufacture of highly efficient photovoltaic solar panels.

In the next few years 1300 secondary schools and colleges, located mainly in remote and rural areas, as well as specialized secondary schools will be equipped with solar collectors. Photovoltaic panels will be installed in more than 600 medical stations in rural areas. Full-scale implementation of these technologies in the coming years allows reducing the load on the grid by 2 billion kWh, to ensure local production of about 2 million Gcal of heat energy, which together will provide energy savings equivalent to over 250 million dollars annually.

Potentially, with the construction and launch of operation especially solar power plants and combined solar-fuel power plants could replace by 2020 up to 15% of used natural gas (1.8 billion cube meters), which will provide economic benefits on the export of gas, calculated by taking into

account the difference between export and domestic prices, which equals to more than 270 million dollars per year, with the price of gas at \$220 per 1000 cube meters.

Along with large solar plants, small solar plants (with capacity less than 10.0 kW), which are not connected to the network, are used for various applications: providing electricity to facilities without centralized supply in rural areas, remote telecommunication devices, traffic signals, and so on.

Demonstrations and pilot projects on the application of solar photovoltaic systems for autonomous power supply of households and objects that do not have centralized power sources which are installed in recent years in Uzbekistan, testify the existing technical capabilities of enterprises of the republic and to start serial production of the necessary equipment for its implementation in remote settlements.

However, the economic efficiency of such plants is inadequate for widespread implementation. Calculations show that their installation in individual housing stocks for a family of 6 people at the current prices on the photoelectric converters and tariffs on electricity pays off for approximately 16 years. Energy savings from traditional energy sources will be 7 billion kWh per year.

Technical possibilities of using wind energy.

Due to the geographical position of Uzbekistan and the resulting adverse climatic processes in ground layer of atmosphere, wind energy in the country has a seasonal character. Specific power of the wind flow in average along the country is 84.0 W/m².

The maximum duration of suitable wind velocities (5-6 thousand hours per year) is characteristic to the Aral Sea region, the mountainous and foothill areas. In desert areas such velocities are observed for 3-4 thousand hours, in the Fergana Valley, the velocities observed are about 1500 hours (Table 8).

Table 8. Total duration in hours of wind velocities at certain stations of the republic

Station	Velocity of wind, m/s		
	>3	>5	<3
Andijan	1760	790	7000
Karakul	3960	1760	4800
Muinak	5540	2960	3220
Nurata	3170	1320	5590
Tamdy	5010	2550	3750
Toytepa	1320	880	7440
Chimbay	4400	1760	4360
Yangiyer	4660	2730	4100
Naryn	1670	400	7090
Haidarkan	2630	980	6130

The estimated gross energy potential of wind energy, based on the data of meteorological observations of long-term (over 10 years) of the wind velocity at heights 10÷15 m at 88 weather stations of Uzbekistan, is equal to 2.22 million toe per year. The technical potential of wind energy in the republic is estimated at 0.43 million toe per year.

At the same time, the gross and technical potentials of wind energy are characterized by extreme spatial non-uniformity. The greatest values are typical for territory of Karakalpakstan and is 0,92 million toe per year - for gross and 0.19 million toe per year - for the technical potential. The lowest values typical for the Fergana region are: 0.04 and 0.02 million toe per year.

Attempts to use wind power plants (WPP) of various capacities in different geographical locations of Uzbekistan (remote areas of Navoi and Bukhara regions, near the Farkhad HPP in Syrdarya region) in the past have not given the expected results.

In recent years, it has gotten some experience in using WPP of serial production with small capacity (3.0 and 6.0 kW) as part of a pilot solar-wind power supply system of the telecommunication object in the foothill area, as well as a WPP with capacity of 6 kW on the flat terrain.

As the estimation of potential of wind energy is carried out according to the observations of wind velocities at meteorological stations in Uzbekistan only at a low height (10 meters), to determine the feasibility of the installation of modern wind turbines on a specific site requires more detailed investigation of wind velocities at different altitudes in ground layer of atmosphere (up to 100m), as well as drafting of wind cadastre.

It is necessary to assess the conditions on wind velocity for modern and large wind turbines and ensure consistency between the periods of peak and the load required for consumers. Currently, SJSC "Uzbekenergo" is implementing a project to assess the potential of wind energy of the country.

Biomass and waste.

Cotton stalks and reeds, the remains of other sectors of crop production, industrial and household waste and livestock waste can be used as an energy source for the generation of heat and electricity (by direct combustion or gasification) in Uzbekistan

From one hectare of land planted with cotton, 2.0 to 4.0 tons of cotton stalks can be removed. The dried cotton stalks from ancient times are used in the rural areas as a fuel. As the calorific value, these cotton stalks are similar to waste of timber harvesting. These stalks can be used as energy source after recycling in form of briquettes or it can be obtained by thermochemical decomposition from the biogas.

Annual gross energy potential of this type of biomass is estimated at 1.1 to 2.2 million toe, and the technical potential (at using thermochemical biomass conversion technology) is from 0.13 to 0.26 million toe.

Another plant resource, is a cane, spontaneously reproduced along the banks of canals and reservoirs in volume of 10-12 million tons.

Resources of timber harvesting are negligible as an insignificant part of the territory of Uzbekistan (3.2% of total land area) is covered by forests: the largest area is occupied by haloxylon, juniper, halophyte. All forests of Uzbekistan are referred to the Group I and commercial logging in them is prohibited. Only reforestation, sanitation and other types of non-commercial fellings are carried out.

In Uzbekistan, more than 30 million m³ municipal solid wastes (MSW) is annually formed, and the total accumulation of these waste at landfills located in settlements is more than 100 million m³. Due to the absence of sufficiently suitable technology for their processing, they are stored without pre-treatment, separation, fractionation to useful components. As a result of

biological processes of decomposition, many landfills release into the environment are decay products: methane, carbon dioxide, etc.

As a result of vital activity of 8 million heads of cattle and 15 million sheep and goats, more than 100 million m³ of organic waste is annually formed. According to preliminary calculations, the total potential of biogas in the country is estimated at 8.9 billion m³. As a calorific value, this corresponds to 6.5 billion m³ of natural gas, accounting for over 10% of the annual needs of the republic on energy sources.

For an accurate assessment of energy potential of biomass, it is necessary to conduct a thorough investigation. At the same time, it should be taken into account that cotton stalks are traditionally used in rural areas, as a fuel for food preparation, and the waste of cereals and other crops, as fodder for cattle and poultry and livestock waste are used as a local fertilizer, and dried naturally as a local fuel.

The preliminary elaborations have shown that the most suitable direction of biomass application in Uzbekistan is organizing the production of biogas by processing biomass and organic agricultural waste. The organization of such production enables us to obtain high quality organic fertilizer, an additional independent source of energy, which reduces greenhouse gas emissions and thus environmental damage caused by organic waste.

The economic effect from the application of bio-fertilizers significantly overlaps the effect of the use of biogas, which is becoming the second most important product for the application of biogas technologies as it can be seen from the calculations of the economic efficiency of biogas plants (Table 9).

Table 9. Exemplary technical and economic indicators of biogas plants of small farms with livestock cattle up to 150 cattle (or up to 30 thousand heads of poultry).

Title	unit	BGP-10	BGP-20	BGP-40	BGP-120
Installing volume of the bioreactors	m ³	10	20	40	120
Cattle farm	Heads	12	24	48	144
Poultry farm	Heads	2500	5000	10000	30000
Preparatory work	\$	639	1074	1790	3408
Equipment of complex	\$	5763	8842	16677	43615
Nominal capacity of generators	kW	3	3	6	12
Installation of equipment, commissioning, training	\$	692	1061	2001	5234
Civil works	\$	6317	11583	17117	36350
In total	\$	13411	22560	37585	88607
Generation of biogas per day	m ³	70	140	280	840
Generation of electricity per day	kW	416	832	1664	4992
The output of gas and methane per day	m ³	29,7	59,4	118,8	356,4
Generation of liquid fertilizer per day	m ³	0,85	1,7	3,4	10,2
The cost of annual output of marketable methane-gas	\$	542,03	1084,05	2168,1	6504,3
The cost of annual output of marketable liquid fertilizer	\$	3102,5	6205	12410	37230
Total income from savings and sales	\$	3645	7289	14578	43734
Tax and other operating expenses	\$	437	875	1749	5248
Net income of the farm	\$	3207	6414	12829	38486
Estimated payback time	years	4,2	3,5	2,9	2,3

Source: LTD «Smart Biogas»

Such biogas systems can be installed in remote rural areas and small farms which do not have access to traditional energy sources. Manufacturing of biogas plants or individual components such as pipe fittings, metal constructions, wires and cables, main mechanical and rubber products, control devices, may be organized at the companies of the republic.

The first attempt to use a biogas plant was made nearly 30 years ago in Toytepa cattle-breeding complex near Tashkent. But for various reasons, including because of the presence of cheaper natural gas in the country, the attempt did not produce the expected results.

A new stage in the development of biogas energy in the country is associated with the implementation of several pilot projects in recent years.

The UNDP project “Promotion of Biogas Technology Development in Uzbekistan”.

As a result of this project in the farm «Milk-agro» at Zangiota district of Tashkent region in 2006, the first biogas plant was put into operation, consisting of 2 tanks with total volume of 120 m³. It is designed for processing manure from 480 conventional heads of cattle while producing per day about 300 cubic meters of gas and more than 10 tons of organic fertilizer.

With the commissioning of the plant, a farm received biogas used for food preparation in the dining room and homes of people, heating buildings and greenhouses, generating electricity for lighting, power supply for mechanized units for milking cows.

At the same time, organic fertilizer was produced, some of which are now used to grow wheat, corn and alfalfa on the sown area of the farm. Another part is produced from the external customers.

LTD “Smart Biogas” biogas complex project on recycling of waste.

To solve the problems of implementation of energy saving technologies and efficient biogas plants for the processing of organic waste of poultry farm LTD “Smart Biogaz” in 2009, the project developed and built the bioreactor with volume of 100 m³, in which biogas and liquid organic fertilizer were generated from waste of poultry farm, and bird droppings, as well as the creation of energy-saving greenhouses with lightweight construction using biogas energy sources in the lands of the farm “MUTALIF BOGISTONI”, located in Bostanlyk district of Tashkent region.

The GEF project “Using biogas plant as an alternative source of energy, heating and electricity generating” within the framework of the Small Grants Program of the Global Environment Fund. In early 2009, a biogas plant was put into operation, the first biogas and bio-fertilizers were received.

The project “the biogas plant in LTD “Yurt rizqi naschilik”” (Kasbin district of Kashkadarya region).

In 2010, a plant was built in accordance with the program of environmental safety of EBRD which is capable of producing nearly 1000 m³ of biogas per day. The raw material for it is animal waste. This amount of biogas is not only enough to meet their own needs, but also to heat the whole village in which it is located. After gas sampling, waste raw materials will be supplied to the field in the form of bio-humus.

“Projects on biogas utilization in the municipal solid waste landfill in the Tashkent’s region in Akhangaran”, which is registered by the Executive Board of the United Nations on Framework Convention on Climate Change under the CDM, with cost of 3.5 million dollars and

with the participation of the Japanese company Shimizu. In accordance with the framework of the project, system for controlled utilization of biogas will be implemented. According to the estimation of Ministry of Economy, this project will reduce annual emissions to about 85 thousand tones of CO₂ equivalent, and income from certificated emissions reductions (CER) sales will be 850 thousand euro per year.

Geothermal resources.

According to the absolute values among all types of renewable energy, the highest integrated energy potential is in the bowels of Uzbekistan, in a form of heat dry rocks (petro-thermal resources) and large basins with hydrothermal waters.

The most promising sources considered for energy applications are petro-thermal resources in huge granitoid massifs at the depth of 4-6 km, heated from 70 to 300 °C in zones of Amudarya geological depressions, Southern Aral, Kyzylkum desert, Chust-Adrasmanov petro-thermal anomalies in the Fergana Valley.

For estimation of the gross potential averaged thermograms were calculate to a depth 3000 up to 3000m, taking into account the average statistical values of the heat flux density and thermal conductivity of rocks. Calculations have shown that the gross potential of geothermal energy contained in the hot dry rocks (petro-thermal resources), in a volume limited by a depth of 3 km and in the area of the Republic of Uzbekistan, is 6700000 million toe. Technical possibilities of using petro-thermal resources are not determined due to absence of appropriate used technologies.

Perennial geophysical, geological, hydrological investigations in Uzbekistan of 8 large artesian basins of gidrogeothermal resources with the following indicators were found, which are given in Table 10.

Table 10. The largest artesian basins in Uzbekistan.

№	Name of basin	Area, thousand km ²	The depth, m	Water temperature, °C
1	Pritashkent	20,0	No data	35÷70
2	Fergana	No data	700÷3000	30÷71
3	Kysylkum	50,0	500	35÷45
4	Zarafshan	8,0÷10,0	600÷1200	45÷55
5	Kashkadarya	No data	650÷1350	50÷75
6	Dehkanabad	6,0÷8,0	No data	30÷49
7	Surkhandarya	8,0÷10,0	2200	27÷70
8	Ustyurt	No data	500÷1500	60÷78

Hydrothermal resources of Uzbekistan can be used for settlements' heating, hot water supply, as well as to generate electricity using a low-boiling heat transfer materials. For these purposes, geological and geophysical, energy-technological investigations and researches should be made comprehensive.

Gross potential of geothermal waters in Uzbekistan is estimated at 170.8 thousand toe. The greatest potential is in Bukhara (56.8 thousand toe) and Namangan (29.8 thousand toe) regions.

The technical potential is not defined as a detailed investigation of geothermal energy resources of Uzbekistan and appropriate technologies for their use has not been conducted. These estimates are based on data from specific geological investigations of deep heat and mass transfer

processes in the formation and distribution of oil and gas fields in Uzbekistan based on results from investigation of groundwater resources, as well as on data from field trips at drilling exploration for oil and gas.

In the 70-80s of the last century in Uzbekistan, it was built quite a significant number of greenhouses on hydrothermal waters. These resources were also used for medicinal purposes.

To assess the possibility of large-scale use of geothermal resources for heating or generation of electricity, a complex research is required. It is necessary to investigate the possibility of using modern technologies of conversion of low-temperature heat transfer agents into energy cycle based on low-boiling heat transfer materials.

Summing up the overall assessment of the possibilities of using renewable energy sources in the country, we note the existing barriers to the development of renewable energy sources:

there is no legal framework to stimulate the development, production of equipment and the purchase of products in the field of renewable energy;

there is no market for RES-products (don't create the conditions for the formation of the market);

there is no appropriate financial environment to attract private capital;

there is no coherent system of training specialists in the field of renewable energy;

material and technical base for scientific research needs to be modernized.

PART 3. ANALYSIS OF THE PROBLEM OF CONSUMERS ACCESS TO ENERGY SERVICES AND TO THE USE OF RENEWABLE ENERGY SOURCES.

3.1. Legislation in the field of using energy resources and consumers access to energy services.

At present in Uzbekistan, the main documents regulating relations in the sphere of energy and renewable energy sources are:

Law of the Republic of Uzbekistan "On the rational use of energy";

Law of the Republic of Uzbekistan "On energy sector";

Law of the Republic of Uzbekistan "On water and water use".

Along with this, during the years of independence, a series of decrees of the President of the Republic of Uzbekistan and Orders of the Cabinet of Ministers were issued, which in some extent covered the various aspects of energy development in the Republic, including the use of renewable energy sources. Among them are the decrees of the President of the Republic of Uzbekistan "On deepening economic reforms in the energy sector of Uzbekistan" on February 22, 2001 and "On activities on social protection of people and support of public utility services" on September 23, 2005, as well as the Orders of the Cabinet of Ministers, which have been adopted to ensure the execution of decrees of the President of Uzbekistan with a specific mechanism to implement them. For example, the positions, as reflected in section 2.4 of the Decree "On the development of small hydropower in the Republic of Uzbekistan" on 28 December 1996, lead to positive practical results that merit deeper attention. However, a holistic system of the legal and regulatory framework on the use of renewable energy in Uzbekistan does not exist. The absence of effective mechanisms to realize the main provisions of the above laws of the Republic of Uzbekistan in the field of renewable energy does not lead to large-scale use of renewable energy in practice.

The law “On the rational use of energy”.

The law was adopted in April 1997, it creates the conditions for the preservation of national energy resources, efficient use of energy and production capacity. The scope of the law is the activity of legal entities and individuals associated with the extraction, production, processing, storage and transportation, distribution and consumption of fuel, heat and electric energy, including renewable energy. Some of incoterms of the law (terms 11, 18, 19, 20) contain provisions relating directly to the renewable energy sources.

In term 11 it is stated that “in order to implement the state policy on rational use of energy the Government of the Republic of Uzbekistan promotes the realization of projects for the implementation of energy efficient equipment and technologies using solar, wind, natural water flows and other renewable energy sources”.

In term 18 it is defined that “in order to financially support the state policy on rational use of energy by the Government of the Republic of Uzbekistan, an extrabudgetary fund for interdisciplinary energy conservation is established”.

Next the sources of replenishment of the Fund are disclosed. In the next term 19 it is stated that “legal entities and individuals engaged in the activities ... on renewable energy use can be subsidized by the energy efficiency fund”. As it can already be seen, the creation of the fund is envisaged in the law, the sources of its replenishment and it is established that this fund can be used for renewable energy projects. However, there is currently no regulatory document, which determines the authority responsible for the creation and making settlements from this Fund and the procedure for consideration and granting from the fund.

Term 20 “The use of renewable energy sources” is entirely devoted to the issues of renewable energy. It is stated:

- “manufacturers of electric and thermal energy, which are not included in the energy supplying organizations, are entitled to leave power in the network of these organizations in the amount and conditions that ensure the most efficient operation of networks and centralized energy sources, agreed with supplying organizations. Energy suppliers are obliged to ensure the reception of energy from these manufacturers in their networks at the defined prices in the prescribed manner.

For power plants that use renewable energy sources, recycling of secondary resources and waste, constructed in accordance with the projects and programs in the field of rational use of energy, the price of electricity and heat energy should accelerate payback of capital investment in the construction of these plants in the terms agreed with the Government of the Republic of Uzbekistan”.

In other terms of the Law, there are appropriate provisions on standardization, certification, international cooperation and the responsibility for violation of the provisions of the Law and etc. These provisions can also be attributed to the field of renewable energy.

As one can see, the fundamental aspects of the activities to support the development of renewable energy sources, the provision on obligatory receiving by distribution networks from the energy generated on the basis of renewable energy sources, as well as the provision on energy prices, ensuring payback of capital investment into the equipment for the use of renewable energy, are legislated by the present law of the Republic of Uzbekistan. However, this is not enough, for these provisions to work in practice, it is necessary to develop appropriate regulations and instructions.

The commission on the economy of fuel and energy resources under the Cabinet of Ministers in 1998 adopted the Actions Plan for the development of regulations related to the Law of the Republic of Uzbekistan “On the rational use of energy”. In the Action Plan, during the period 1998-99, developing and approving more than thirty acts, rules, regulations, instructions, etc.. were provided. At present, only part of them are developed and approved. Regulations concerning renewable energy are not approved, so the terms of the Law on renewable energy sources do not work today.

Apparently, it is also required to develop a Regulation on cross-sectoral extrabudgetary fund for energy conservation, keeping in the mind that sources of replenishment of the fund will be expanded and that the fund will be used to stimulate the development of renewable energy.

Thus, the term of the Law “On the rational use of energy”, associated with renewable energy are not fully supported in volume by the appropriate acts (rules, regulations, instructions, etc.).

The Law “On water and water use”.

This law was adopted in 1993, and then thereto amendments were adopted. The law describes the problems of water sector of the republic, including the use of water resources for the economy. Chapter XIV “Using of water objects for industrial purposes and for the needs of energy sector” contains a term 58 “Using of water objects for the needs of hydropower”, which states that “the using of water objects for the needs of hydropower is carried out taking into account the interests of other sectors of the economy, as well as in compliance with the integrated use of water...”. This law is the same as the previous one, with respect to renewable energy sources, (hydroelectric power plants) and is decisive, but thereto amendments and appropriate regulations are required in accordance with the Law “On water and water use” hydropower potential of the country can be used for the needs of energy sector. However, the law does not define requirements to ensure the integrated use of water resources; it does not regulate the relationship between the owner of the irrigation channels and investors wishing to invest into the construction of hydroelectric power plants.

In 2009, in the country, the Law “**On energy sector**” was adopted. This important piece of legislation in the field of electricity generation came after the above two laws, but in terms of the provisions related to renewable energy, it did not only expand the opportunities and incentives to attract private investment in energy generation based on renewable energy sources, but limited these features, and in some positions brought conflicting judgments.

Thus, in term 10 of this law associated with “Companies for the generation of electrical energy”, it is stated that: - “Thermal power plants, thermoelectric plants as well as power plants using renewable energy sources connected to the power grid, may be state or private property”. Thus, the legislation provided possibility to create power plants based on the use of renewable energy sources by entities of different forms of ownership, including small businesses and individuals. Further, this term concludes with a statement of the following provision: “Hydro power plants connected to the power grid, owned by the state”. Classification of hydropower plants to the state ownership is understandable, since they are mainly built on rivers and reservoirs for irrigation purposes. But at the same time, it can mean that the scope of the use of water resources of the republic can not be held by private investors. At least, it can not be the owner of the hydroelectric power plant, if it is connected to the power grid. If we agree with the provisions of this Law, then, in Article 20 of the chapter “The use of renewable energy” of the above-mentioned Law “On the rational use of energy”, it would make changes, that hydropower plants are not related to plants

using renewable energy sources, which in turn contradict the established definition of renewable energy sources. However, this term could be interpreted as follows: a private investor could get permission to build a hydroelectric power plant, but the plant can not be connected to the power grid and electricity generated on it can only be used for personal needs of the investor or the investor must build its own power grid to sell the electricity to other consumers. This limits the interests of private investors, since it may encounter difficulties in selling their products.

In the 12th term of the law, it is stated: “Legal entities and individuals can produce electrical energy for their own use”. As one can see, this term does not provide the exception for the electric energy generation on hydroelectric power plant for its own generation, hydroelectric power plants (including small and micro power) can be built at the expense of private capital. Then it is established that “the activity of electricity generation for its own use, is not subject to licensing”. If these provisions relate to the generation of electrical energy for their own use through the use of renewable energy sources, the next paragraph of this article completely restricts the use of renewable energy sources: “legal entities and individuals generating electricity for their own use, and the connection of electrical generation units to the territorial power grid is prohibited. Sales by legal entities and individuals of power generated for their own use, to other legal entities and individuals may be through their own electrical networks prescribed by laws”. We note that in the present, in any legislation, such order does not exist.

Thus, the provisions of terms 10-12 of the Law “On energy sector” should be revised.

It is necessary that any legislation would be supported by-law (regulations, instructions, procedures, etc.), otherwise it will be only a declaration.

3.2. Legislation on the sector of renewable energy use.

The use of renewable energy for the development of Uzbekistan is obvious and necessary in order to provide energy, environmental and economic security, and to provide sustainable energy development of the republic in terms of independence.

State policy in the sector of renewable energy in Uzbekistan takes into account the experience of the development and large-scale use of renewable energy sources in a number of countries. Practice shows that only the definition of specific goals and objectives in the sector of renewable energy and comprehensive governmental support promotes the competitiveness of renewable energy in relation to traditional energy technologies. A feature of the current situation on renewable energy in Uzbekistan is that its resources except hydropower, is currently still not widely used in commercially relevant scale.

Monitoring of laws, regulations and decisions of state authorities, adopted in recent years has shown that the existing legislative and regulatory framework of the Republic of Uzbekistan regarding the use of renewable energy sources requires a substantial development and preparing of the individual legislative acts, in which should be reflected the legal, economic and financial, and administrative mechanisms to support the development of renewable energy use. These laws should include a set of incentives for the implementation of new resource-saving and environmentally friendly technologies and modern equipment, and most importantly, bringing up the high culture of energy consumption, both for the industry and at home.

In this regard, a number of agencies and organizations have prepared different versions of the draft Law of the Republic of Uzbekistan on renewable energy. In pursuance of the Resolution of the Cabinet of Ministers (№ 81 from 19.03.2013) by the Ministry of Economy, the Academy of Sciences, SJSC “Uzbekenergo” with the participation of specialists from the Ministry of Finance,

Ministry of Foreign Economic Relations, Ministry of Justice, the State Tax Committee, the State Customs Committee, the State Committee on Nature Protection, the Agency “Uzstandard”, the Fund for Reconstruction and Development of Uzbekistan, the State Inspectorate “Uzgosenergonadzor”, “Association of Alternative Fuel and Energy” on the basis of the analysis and taking into account the previously prepared versions of the draft Law “On renewable energy sources” was prepared and submitted to the Cabinet of Ministers for consideration by the Legislative Chamber of Oliy Majlis of Republic of Uzbekistan.

The purpose of the draft Law is the formation of common legal standards to ensure priority development and use of renewable energy sources for sustainable development of the country and environmental protection.

The law is designed to solve the following problems:

- to define main terms, used in RES;
- to specify the basic principles of state policy in the sector of renewable energy;
- to define the tasks of state regulation of relations between subjects in the use of renewable energy sources;
- to develop the legal rules governing the activities on the use of renewable energy sources, as well as the financing and promotion of its use;
- to implement antitrust requirements on using renewable energy sources;
- to determine the special state authority in the sector of renewable energy and its powers in using renewable energy and others.

The draft law contains the following chapters and articles.

Chapter 1. General Provisions.

Article 1. Purpose of the Law,

Article 2. Legislation on renewable energy sources,

Article 3. Definitions.

Chapter 2. The principles of state policy and state regulation in the field of application of renewable energy resources.

Article 4. Principles of State policy in the field of development of renewable energy use,

Article 5. Authorities of the State Administration in the field of development of renewable energy use,

Article 6. Powers of the Government of the Republic of Uzbekistan,

Article 7. Powers of the special state authority,

Article 8. Powers of the state supervision,

Article 9. Powers of the local state authorities, in the field of development of renewable energy use.

Chapter 3. Manufacturing, transmission, sale and consumption of energy, generated from renewable energy sources.

Article 10. Manufacturing, transmission and sale of electricity, generated from renewable energy sources,

Article 11. Certificate of origin of electrical and heat energy from renewable energy sources,

Article 12. The requirement for certification of the origin of energy,

Article 13. Manufacturing of thermal energy and biogas from renewable energy sources.

Chapter 4. Tariffs for energy from renewable energy sources, restrictions on the activities of natural monopolies, standardization and certification in the field of renewable energy.

Article 14. Tariffs for the energy generated from renewable energy sources,

Article 15. Standardization and certification in the field of renewable energy,

Article 16. Restrictions on activities of natural monopolies in the field of renewable energy.
Chapter 5. Rights and responsibilities of manufacturers, consumers of energy from renewable energy sources.

Article 17. Rights of manufacturers,

Article 18. Responsibilities of renewable energy manufacturers,

Article 19. Responsibilities of renewable energy consumers.

Chapter 6. Final Provisions.

Article 20. Economic incentives,

Article 21. Financing of the activities in the field of renewable energy use,

Article 22. Responsibility for violation of legislation in the field of renewable energy,

Article 24. Law entering into force.

The adoption of the Law “On renewable energy sources” will allow to improve the legal framework for the development of a unified state policy in the sector of renewable energy, to create administrative mechanisms to support the development of the use of renewable energy, and to strengthen ways of interaction for coordination and cooperation between the subjects in using renewable energy sources.

3.3. Assessment of the situation on the provision of sustainable energy services and supporting the use of renewable energy in rural areas of Uzbekistan.

3.3.1. Provision of sustainable energy services for consumers in rural areas.

Uzbekistan is a country with a developed agricultural sector, the distinctive features of which is: irrigated agriculture with the cultivation of cotton, corn, vegetables, fruit; animal breeding mostly distant pasture both in the foothill, mountain and semi-arid areas.

In rural areas, 60% of the country’s population resides in more than 11 thousand rural settlements (RS), in conjunction with institutions on education, health care, public utilities, communications, etc.

Besides, in rural areas, there are objects of the mining, oil and gas industry and water industries. Thus rural areas differ from each other both in the natural and climatic conditions (mountains, foothills, semi-deserts, deserts) and by the presence in their territories of reserves of water and mineral raw materials. These factors are important when considering the issue of access to energy resources and providing sustainable energy services. In view of the foregoing, it should be noted that the Government of Uzbekistan through many of its long-term, average, and short-term plans, orders and decisions has sought, and intends, in the current period and in the future to achieve a sustainable energy supply in rural areas, as close as possible to the conditions of energy supply of large industrial enterprises and cities. In this order, developed oil and gas sector was created in the country, providing with fuel resources the electric power and other sectors of the economy.

In particular, as a result of the program on gasification of RS, adopted in 2000, the average annual level of availability of natural gas in rural areas along the country has increased in total from 65.9% in 2000 to 83.7% in 2010, with the differentiation along individual region, at least 68.8% in Kashkadarya region to 95.0% in Bukhara region.

The degree of electrification in the country is 99%. During the period from 1960-1980, in Uzbekistan, further development of agriculture large-scale projects were implemented by the government for the development of machine irrigation with cascades of large electric water pump

lifting stations, specifically the Amu-Bukhara, Karshi main channels, the system of machine channel Sherabad and others. Besides, previous systems of channels have been built: Great Fergana, Great Namangan, Tashsak, Yuzhnogolodnostepsky, Dorgom and several others with a lot of hydraulic structures. There was also built large, medium and small water reservoirs for irrigation. For effective work of a significant number of water facilities, branched systems of power supply were created at voltages: 110, 35, 10, 0.4 kV, which are attached to the main transmission and distribution electric system.

On 1588 state pumping stations of the Ministry of Agriculture and Water Resources of the Republic of Uzbekistan, 5003 units were established with total capacity of 3.75 million kW, consuming more than 8.0 billion kWh per year. This represents more than 16% of all electricity generated in the country with a total water supply of about 6817 m³/s for irrigation of 2.4 million hectares from 4.3 million hectares of irrigated land. Every year, all the pumps pumped about 59.0 billion m³ of irrigation water [16]. The mean annual power consumption of 11 large reservoirs of water is more than 35.34 million kWh. Consumption of electric pump stations is shown in Table 11.

Table 11. Consumption of electric pump stations.

Region	Amount of pump stations	Consumption of electric energy, million kWh
Andijan	13	289,5
Namangan	17	479,5
Fergana	17	164,8
Samarkand	12	146,4
Total	59	1080,2

a significant number of electric pump stations for water supply of facilities of oil and gas industry, the mining industry, shift settlements of geological exploration parties, and oil and gas extraction facilities, reception centers and cotton processing enterprises, reception centers and food processing enterprises, facilities of small business in the sector of provision of social services and so on are located in rural areas of Uzbekistan.

All of the mentioned objects in the energy aspect are “distributed” power facilities with an installed capacities ranging from a few tens of kW to tens of MW.

Due to the deterioration of the electric grid equipment of distribution grids, which was built in 1960 - 1970, lagging in their reconstruction and modernization in order to meet the increased demand for electricity supply and energy services by the Government of the Republic decided to modernize electric grids with voltage of 110/35/10/0.4 kV; to build transmission lines with voltage of 500/220 kV.

However, the presence of extended electric grids with voltage of 35/10/6/0.4 kV in rural areas with low-density electrical loads along the seasons and during the day, in a sharply continental and dry subtropical climate is one of the reasons for high electricity losses, reaching in some regions to 16% - 18%, the result of which is a violation of sustainable access to energy and energy services in rural areas.

With this in mind, it is considered by the government as a possible option: the development of decentralized energy supply in rural areas with a wider use of energy-generating sources of various power levels with the maximum use of local energy resources, including renewable energy.

PART 4. PLACEMENT OF POWER GENERATING FACILITIES BASED ON RENEWABLE ENERGY SOURCES IN RURAL AND REMOTE AREAS OF THE COUNTRY.

The use of renewable energy in Uzbekistan is based on a set of criteria, approaches, specially:

- availability of renewable energy resources, the investigation of their regime features;
- availability of effective technologies and techniques that convert renewable energy into electricity and thermal energy;
- accounting of cadastre of territorial resources for the installation of plants and energy complexes on the basis of RES;
- the degree of energy supply of regions;
- ecological situation in the location of potential energy complexes of the RES;
- economic, financial and social benefits from the use of renewable energy sources.

In view of these criteria as a priority in Uzbekistan, hydroenergo potentials of natural and artificial waterways are used.

Based on the above approaches for the effective use of the hydropower potential of the rivers, waterways of the republic and created hydraulic structures, improvement of energy supply in rural areas, by the Cabinet of Ministers of the Republic of Uzbekistan, by the Decree number 476 from 28.12.1995 a program “On the development of small hydropower in the Republic of Uzbekistan” was adopted, according to which there have been built and put into operation the following small hydro.

1. Hydro power plant at Tupolang water reservoir in Surkhandarya region;
2. Hydro power plant at Akhangaran water reservoir in Tashkent region;
3. Hydro power plant-2 at Andijan water reservoir in Andijan region;
4. Hydro power plant at Gissarak water reservoir in Kashkadarya region;
5. Urgut Hydro power plant on Dargom-Taligulyan water and energy tract in Samarkand region;
6. Ertashsay Hydro power plant on Ertashsay river in Tashkent region.

To stimulate the development of the construction of small hydropower plants, the above decree envisaged the use of these support mechanisms:

- use of special feed-in tariffs for electricity generated by small hydropower plants within the average selling price of electricity in the whole, along the energy system, based on bilateral agreements with energy supplying organization;

- creation of a special fund of resources received from the sale of electricity generated by small hydropower plants and its use for the development of small hydropower in for reinvestment”.

In the period of 2016-2025 construction and commissioning of a number of small hydro power plants with indicators from those given in Part 2 are planned.

Putting into operation these HPP can improve access to energy and energy services in rural areas.

In the framework of the UNDP project in 2003 “**Clean Energy for Rural Communities in Karakalpakstan**” 15 solar photovoltaic plants (SPVP) are established with a capacity of 100W in the village Kostruba, Karauzyak districts for power supply of villagers houses; 10 SPVP with power of 200W for drinking water lifting. This allowed villagers to gain access to electricity and clean

drinking water for households. In addition, it is provided that there is a conditional reduction of greenhouse gas emissions in the amount of 188 tons per year.

Within the project “**Alternative sources of energy to support the social sector representatives**” implemented with the financial support of Social Initiatives of Support Fund, wind-solar energy complexes of low capacity was established (total installed capacity of up to 3 kW) in the following rural health units (RHU) and hospitals:

RHU Karauzjak, Karauzjak district of the Republic of Karakalpakstan;
RHU Mulik, Takhtakupir district of the Republic of Karakalpakstan;
RHU Turakul, Karshi district of Kashkadarya region;
RHU Kushtangali, Kushrabad district of Samarkand region;
RHU Zhonbulok, Kushrabad district of Samarkand region;
RHU Bodihavo, Denou district of Surkhandarya region;
RHU Uzbekistan, Chartak district of Namangan region;
RHU Fozilmon, Hanabad district of Andijan region;
RHU Muzbulok, Bakhmal district of Jizzakh region;
RHU Ohunboboev, Saraosiyo district of Surkhandarya region;
CDH Muinak, Muinak district of the Republic of Karakalpakstan;
City Hospital of Nukus of the Republic of Karakalpakstan;
As well as - in handicraft workshops and farms:
Weaving workshop, Kegeyli region of the Republic of Karakalpakstan;
Carpet weaving workshop, Dehkonabad district of Kashkadarya region;
Carpet weaving workshop, Boysun district of Surkhandarya region;
Wood carving workshop, Zangiota district of Tashkent region;
Handicraft workshop on manufacturing of satin, Margilan city of Fergana region;
Farm, Zaamin district of Jizzakh region.

Besides that, 24 wind and solar power complexes were installed on 25 sites for mobile communications (MCF) in 9 regions of the country, with a total capacity of more than 75.0 kW.

The results through the use of wind and solar energy complexes with low power in these social facilities along with getting access to electricity and energy services are:

- improved power supply of expensive medical equipment of RHU, resulting in a 3-fold increase in the number of people receiving treatment procedures, improved access to sustainable health care services;
- ensured the required storage conditions of medicines in the RHU, especially expensive, in a hot climate of arid zone;
- increased access to information services for businesses and the public due to a more stable power supply of MCF in many regions of the republic.

It should also be noted the positive experience put into operation:

- 18 SPVS with installed capacity of 100W, staffed with a specialized controller, for use in the centers of control and accounting of natural gas in trunk pipelines of system “Uztransgaz”;
- 21 SPVS with an installed capacity of 100 W for the electrification of houses in the village Kastruba of Tahtupyr district of Karakalpakstan;
- 6 SPVS with an installed capacity of between 60 W and 500 W for the needs of the State Committee on Ecology and Environment;
- 5 SPVS with an installed capacity of 100 W to 200 W to provide electricity to departmental lines;

- 2 SPVS with an installed capacity of 1,000 W and 1,200 W to provide electricity to rural health centers;

- more than 10 SPVS with an installed capacity of 100 W to 300 W on the orders of private individuals.

Monitoring of the operation of the above SPVS showed their sufficient reliability and the ability to operate in a hard climate zone, which is characterized by high wind forces, temperature drops, heavy snowfalls, etc.

In December 2014, in accordance with the Memorandum of Understanding between the Ministry of Economy of the Republic of Uzbekistan and the Ministry of Commerce, Industry and Energy of the Republic of Korea, a test solar photovoltaic power plant of 130 kW was put into operation in the Pap district of Namangan region at the expense of grant funds of the Korean side in the volume of 700.0 thousand US dollars.

The purpose of the project is the improvement of power supply in rural settlements; testing the efficiency of solar photovoltaic modules produced by 4 companies with different technologies, including:

1. Manufacturer: Company Hanhwa, Modules on polycrystalline silicon solar cells. The block of 198 units with a unit capacity of 250 W and a total installed capacity of 50 kW.
2. Manufacturer: Company JSPV, Modules on single crystal silicon solar cells. The block of 198 units with a unit capacity of 250 W and a total installed capacity of 50 kW.
3. Manufacturer: Company S-ENERGY, Modules on polycrystalline silicon solar cells. The block of 72 units with a unit capacity of 250 W and a total installed capacity of 18 kW.
4. Manufacturer: Company Topsun, Modules on single crystal silicon solar cells. The block of 24 units with a unit capacity of 400 W and a total installed capacity of 9.6 kW.

Uzbekistan is implementing an investment project: “**Construction of a solar photovoltaic power plant with capacity of 100 MW in the Samarkand region**”, with the total cost of 275.83 million US dollars.

The objectives of the project are:

- the use of solar energy for electricity generation in Uzbekistan over the long term;
- increasing the stability of the power system;
- increasing the reliability of power supply in Southwest part of the power grid;
- increasing the reliability of power supply in facilities of the national economy and to the population of Samarkand region.

Project implementation period: 2014 - 2016 years.

Commissioning of the solar power station will provide access to electricity and energy services to consumers located in Pastdorgom and neighboring districts of Samarkand region.

In accordance with Presidential Decree No.DP-4707 from 03.04.2015, the implementation of the following investment projects in the field of solar photo electricity are provided.

1. Construction of a solar photovoltaic power plant with capacity of 100.0 MW in Namangan region in 2017 - 2019, with a target cost of the project 210.0 million US Dollars.

2. Construction of a solar photovoltaic power plant with capacity of 100.0 MW in Sherabad district of Surkhandarya region in 2019 - 2021, with a target cost of the project of 210.0 million US Dollars.

The benefits of implementing these SPES are the access to electricity and energy services to consumers located in rural areas of Namangan and Surkhandarya regions.

In conclusion we note the priority activities for the development of renewable energy in Uzbekistan:

1. The early entry into force of **the Law on renewable energy sources**;
2. Speed up the process of determining the authority which is responsible for the development of renewable energy in the country;
3. Launching the activities to stimulate the manufacturers and consumers of solar energy and biogas, providing them tax and customs privileges and preferences;
4. Establishment of special guaranteed tariffs for buying electricity produced from renewable energy sources, as well as commitments for grids to buy this electricity;
5. Determination in the energy balance of energy supplying and consuming organizations with obligatory share of energy generated from renewable energy sources; Green quotas;
6. Establishment of a special fund to promote the latest developments in the sector of renewable energy;
7. Implementation of special programs and demonstration projects; for example, the project **“1000 solar rural houses”**.

PART 5. THE RECOMMENDATIONS FOR IMPROVING EFFICIENCY OF POWER SUPPLY SYSTEM IN RURAL AND REMOTE AREAS AND IMPLEMENTATION OF ADVANCED TECHNOLOGIES IN THE FIELD OF RENEWABLE ENERGY SOURCES.

Rural territory of Uzbekistan is diverse on geographical conditions; the degree of economic development; the availability of energy resources; development of systems of gas, electricity and water supply.

Relatively, the following components of the rural territory of the country can be distinguished. Mountain, foothill areas, covering territories with the presence of rivers, artificial streams and which are from ancient times the most explored and developed areas of the country with a developed system of energy supply.

The plains and steppe areas, closely adjacent to the mountainous and foothill areas with the developed system of artificial irrigation and also quite developed in the economic and social aspects with a less developed system of energy supply.

Semi-desert areas with low water availability, but intensively developed due to the possession of rich mineral resources with insufficiently developed system of energy supply.

Desert area with practically absence of surface water resources, but also has the opportunities to develop the mineral resources as well as the distant pasture cattle rearing with low levels of the development of energy supply system.

In view of the above possibility of providing access to energy resources, energy services, water supply in various rural and remote regions and possibilities of their improvement are different.

Ways and possibilities of enhancing the efficiency of power supply in rural and remote areas may be carried out on the basis of technological modernization with transition to the decentralized generation of electricity and heat energy with the use of local energy resources, as a priority - renewable energy.

It is advisable forcing the use of hydropower resources of natural and artificial waterways in the republic for electricity generation and enhancing the efficiency of electricity supply in rural

areas. Energy, economic, environmental, financial and social benefits from electricity generation by hydroelectric power plants of different capacity levels are higher compared to using other types of renewable energy. There is a long experience of efficient use of hydropower resources in the republic, as well as scientific and technological industrial base, and sufficient scientific, technical, human resources in the field of hydropower, etc.

Taking into account the presence in the Tashkent region of 19 non gasified RS located in Chimgan - Charvak recreational zone, it is recommended to implement a demonstration project: **“Providing access to energy resources and energy services to residents of rural settlement “Nanay” in a remote district of Tashkent region through the construction of small hydropower plant with capacity up to 1000 kW on Aksarsay river”**.

The benefits from the implementation of the project are:

Improving electricity and heat supply of homes and objects of social infrastructure (schools, rural hospitals) located in the village of “Nanay”.

Environmental benefits, reduction of emissions of harmful substances into the environment as a result of the possibility of transition to electrical heating supply in food preparation, hot water supply and heating, instead of using coal or wood. Creation of new jobs, production in the village, etc.

Proven technology for energy supply of RS through the construction and use of small hydropower plants will expand its application for providing sustainable energy supply of many RS located close to waterways.

A large part of the territory of Uzbekistan in the semi-desert and desert zones in Navoi, Kashkadarya, Surkhandarya, some areas of Tashkent, Jizzakh, Samarkand regions, the Republic of Karakalpakstan is exposed to influence of wind flows in surface layers of the atmosphere, which is sufficient for their use in energy sector. These territories also have energy potential for solar radiation, sufficient for its use in energy needs. These considerations are confirmed by the experience of using over 60 wind and solar power generating complexes in power supply systems of low-power facilities in rural areas of six regions of the republic.

In this connection, it is recommended to implement a demonstration project: **“Proving access to energy resources and energy services to residents of rural settlement “Muzbulak” in a remote district of Jizzakh region through the construction of wind and solar power complex”**.

The benefits from implementation of the project.

Development and testing of innovative technology of clean energy generation through the conversion of wind and solar energies into electrical energy for later expanded application of technology.

Improving electricity and heat supply of homes and objects of social infrastructure (schools, rural hospitals), located in the village of “Muzbulak”.

Environmental benefits are the reduction of emissions of harmful substances into the environment as a result of the possibility of transition to electrical heating supply in food preparation, hot water supply and heating, instead of using coal or wood. Creation of new jobs, production in the village, etc.

As a result of the Aral Sea crisis, a significant part of its water areas are bared, there is an intensive removal by wind flows of a large mass of sand spreading throughout the whole territory of the country and especially to the territory of Karakalpakstan, adjacent to the sea. The greatest damage from this crisis that the rural population faced is due to pollution, poor access to safe drinking water, fuel and heat supply, electrical services.

Since Karakalpakstan is located in north-west of Uzbekistan, and is characterized by extreme continental climate with low temperatures in winter, reached the value of $-20^{\circ} \div -26^{\circ}\text{C}$, the living conditions of its population are greatly exacerbated both in the coldest periods of the year, and in summer when the air temperature reaches $+40^{\circ} \div +45^{\circ}\text{C}$, with a lack of clean drinking water, water for irrigation and water supply of a significant number of large and small cattle, which are an important component of the agricultural sector of Karakalpakstan.

In view of the above, taking into account the presence on the territory of Karakalpakstan, and significant number of non gasified rural settlements, it is recommended to implement a demonstration project: **“Providing access to energy resources and energy services to residents of rural gathering of citizens (RGC) “Nazarkhan”, Amudarya district of Karakalpakstan through the use of advanced energy efficient technologies in heat supply using renewable energy”**.

RGC “Nazarkhan” covers settlements Nazarkhan, Jalpyk Jap, Kyryk Ozek, Kok Darya, Mayli kul, Beck. The population accounts for 3511 people, including 1760 women. The number of households is 679, which are home to 692 families. The number of cattle, on the RGC is 1897, 736 sheep and goats, 3924 birds. 189 households are not gasified. In the gasified settlements, there is a very low pressure of natural gas in distribution pipelines and frequently power outages, intensifying in autumn and winter. Therefore, the population of the RGC for heating their homes, food preparation, and hot water supply on sanitary and domestic designation use wood of tugai forests as fuel. This leads to the destruction of natural clean air plants in tugai forests which is an ecological critical area. It is consumed more than 4900 m^3 of harvested wood with destruction of more than 200 hectares of tugai forests per year and release into the atmosphere of 3.929 tons of CO_2 equivalent.

Accordance with the framework of the project, it is planned:

- receiving the biogas from animal waste;
- production and application of environmentally friendly fuel briquettes from biomass (reeds, twigs, etc.) for food preparation and heat supply;
- use of energy-efficient stoves in homes with a lower amount of consumed fuel with effective satisfaction of the needs of household;
- use of solar energy technologies for the processing of agricultural products, in the food preparation; solar and wind power facilities of small power in power supply systems of buildings and other facilities.

The benefits from the implementation of the project.

Improving heat supply and electricity of houses and social facilities in RGC “Nazarkhan” in the area of the ecological crisis of the Aral Sea.

Environmental benefits are the reduction of emissions of harmful substances into the environment as a result of the possibility of using energy efficient stoves for heating, fuel briquettes from biomass, clean energy from solar and wind power facilities for power supply, preservation of tugai forests in the protected areas.

Social benefits.

Creation of new jobs and productions in the village. Promotion of advanced environmentally safe technologies to remote rural areas, raising public awareness in rural areas about the energy efficiency and opportunities of renewable energy technologies. The ability to expand the use of the developed technologies and systems in other RGC in the area of the ecological crisis in the Aral Sea.

There are 25 especially important large and system channels of water supply with a total length of 3270 km in the territory of Uzbekistan. A special feature of them is cross-sectoral and inter-regional designation on water supply of facilities in various sectors of the economy. There are 14 large hydro units (HU), ensuring water regulation in large and system channels taking into account the water needs along the whole year.

Besides that, in the territories of the various regions of the country, a significant number of regional channels are operated with cross-sectoral designation. The total length of this class of channels is greater than a few thousand kilometers. There is a significant number of HU, power supply of which is carried out through power lines with voltage of 10/6/0.4 kV of considerable length. Due to the considerable length of the above-mentioned channels and by laying their routes through remote areas located on them, HU feels shortage in power supply due to physical deterioration of electrical units of power lines of external power supply systems of HU which was built 30-40 years ago. This breaks the efficiency of the HU.

In view of the above, it is recommended to implement a demonstration project **“Providing access to energy resources and energy services of Ak-Karadarya hydropower unit on the river Zarafshan in Samarkand region through the use of hydropower resources in the area of hydropower unit”**.

Ak-Karadarya hydropower energy system unit is located in the area of Samarkand-Bukhara, self-sufficiency in electricity which does not exceed 47%. Transfer of electricity from other energy subsystems is carried out to cover the deficit. Herewith the losses of electricity in the networks are about 1.0 billion kWh per year. At the same time, entering restrictions on power consumption for many hours is practiced, especially in autumn and winter.

HU is a low-head reinforced concrete dam with 7 overflows and 5 water intake holes. The height of the dam is 6.5 m., the maximum head on the threshold is 4.0 m, the length of the front is 106 m.

Appointment of hydropower unit is as follows:

- to provide a guaranteed water intake to the main channels Kurbanabad and Central-Miankala which provide water for 84.7 thousand hectares of irrigated land, including 56.7 thousand hectares of existing irrigation;
- to eliminate the possibility of entering the bottom and large suspended sediments into mentioned main channels;
- to ensure proper distribution of flood flows between the rivers Karadarya and Akdarya;
- to prevent the overflow of water into the river Akdarya at a low flow rates, providing a water supply along the riverbed of Karadarya to Damhodzhin hydropower unit for filling Kattakurgan water reservoir and water supply to the main channels (Hodge, Hatyrchi and etc.).
- to prevent the overflow of water into the river Akdarya at a low flow rates.

The presence of drops on the hydro unit ~ 4 m and acceptable average monthly water discharges (Table 11) allows creating a hydroelectric power plant with an installed capacity of up to 1,0 MW.

Table 11. Average water discharge along months.

Month	1	2	3	4	5	6	7	8	9	10	11	12
Water discharge, m ³ /s	33,0	28,0	8,3	10,0	64,0	103,0	89,0	51,0	18,0	8,0	9,0	18,0

The benefits from implementing the project.

Electrical energy generated in the hydroelectric power plant in the first place can be used in the Ak-Karadarya hydropower unit and cover its energy needs for power supply, drives of the gates, the lighting of the dam and the surrounding area, the building of control station. In addition, due to cheap electricity, heating the buildings of hydropower unit can be carried out, providing hot water to operating personnel. At the same time, Ak-Karadarya hydropower unit proceeds to self-sufficiency on energy supply and the costs of budget for energy supply will be saved.

Excess electricity can also be used:

- for power supply of hydropower unit located near the residential village Farkhad in order to improve the reliability of electricity, heat supply of residential houses, social facilities, schools, kindergartens, rural medical centers, etc., which are currently being implemented with multi-breaks;
- to supply a nearby (up to 2 km) Samarkand cigarette factory (SSF), the total installed power capacity of production lines, electrical equipment and electric drives for various purposes, which are 2.5 MW.
- to supply the surrounding plants of concrete products; quarries for mining the construction materials.

Social benefits.

Creation of new jobs, both during the construction period of HPP and during its operation.

Promotion of advanced environmentally safe technologies of electricity generation on the basis of the available hydropower resources. The ability to expand the use of technical solutions on other hydropower units, improving water supply and efficient use of water resources.

For indigenous improving of energy supply of rural areas of all regions and Republic of Karakalpakstan, the investigation and analysis of their current and future electricity has to be conducted on heat supply for a period up to 2030-2040, to prepare preliminary technical and economic substantiating materials on the use of advanced renewable energy technologies, to develop integrated regional programs for energy supply of the rural regions of the country for a period up to 2030-2040.

It is necessary to develop and submit for consideration to the Oliy Majlis (Parliament) of the Republic of Uzbekistan a set of laws in the field of renewable energy: “On hydropower”, “On solar energy”, etc.

To develop and make changes to the Law of the Republic of Uzbekistan “On energy sector”, to articles on the independent manufacturers of electrical and thermal energies and their access to the electrical, heating networks; on the mandatory purchase by the regional energy supplying enterprises of the electric and thermal energies generated by independent power generating enterprises of different ownership forms with the use of renewable energy sources, etc.

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