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Effective management of combined renewable energy resources in Tajikistan

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ABSTRACT

Water is needed mostly in summer time for irrigation and in winter time for generation of electric power. This results in conflicts between downstream countries that utilize water mostly for irrigation and those upstream countries, which use water for generation of electric power. At present Uzbekistan is blocking railway connection that is going to Tajikistan to interfere to transportation of the equipment and materials for construction of Rogun hydropower plant. In order to avoid conflicts between Tajikistan and Uzbekistan a number of measures for the utilization of water resources of the trans-boundary Rivers Amu-Darya and Sir-Darya are discussed. In addition, utilization of water with the supplement of wind and solar energy projects for proper and efficient management of water resources in Central Asia; export-import exchanges of electric energy in summer and winter time between neighboring countries; development of small hydropower project, modern irrigation system in main water consuming countries and large water reservoir hydropower projects for control of water resources for hydropower and irrigation are also discussed. It is also concluded that an effective management of water resources can be achieved by signing Water treaty between upstream and downstream countries, first of all between Tajikistan and Uzbekistan. In this paper management of water as renewable energy resource in Tajikistan and Central Asian Republics are presented.

1. Introduction

Rational utilization of hydro, wind and solar energy in Central and Southern Asia is an important problem today. It is connected on one hand with an opportunity of use of a huge renewable energy potential for the production of electric power, and on the other hand with the necessity of the preservation and improvement of ecology of environment by the prevention of pollution of reservoirs, ground and air by different kinds of wastes of non-renewable energies utilization and decrease in the cutting down of woods (Sirojev, 1984). Around 75% population of these countries live in the countryside and mountain territories where there is shortage of energy resources, but there are a lot of rivers that are the major source of hydro power.

Countries like Tajikistan, Kyrgyzstan and Pakistan possess great potentialities of utilization of energy of the sun, water and biomass. Furthermore, traditional life style of inhabitants of villages, where practically, in each yard there is the availability of water resources and hydro-power origin for production of electric power. However, till to-date these potentialities in the countries are not used to their reasonable potential. Absence of energy is directly affecting the population resulting in substantial lower standard of living, in general to the inhabitants of villages and specifically living in the mountain areas (Sirojev, 1999; Renewable energy in Kyrgyz Republic, 2010; Zaigham and Nayyer, 2005).

In Central Asia the problem of water is one of the most important problems of present days. Tajikistan and Kyrgyzstan, as upstream countries, are situated in the catchment area of rivers Amu-Darya and Sir-Darya; and Uzbekistan, Turkmenistan and Kazakhstan, as downstream countries, are in the zone of utilization of water resources (Karimov et al., 1995). At the same time water is needed mostly in summer time for irrigation and in winter time for generation of electric power. It can bring to conflicts between countries that utilize the water mostly for irrigation and those that use water for generation of electric power.

In utilization of renewable energy resources (RER), different schemes of combined or mutual supplementary utilization of wind-solar energy, hydropower-wind energy, hydro-wind and solar energy utilization were discussed and developed (China new and renewable energy, 2000; Marupov et al., 1999). Combined schemes have a number of advantages as reliability of the power supply, stability of output parameters as power, voltage, frequency, effective management of the resources etc. As is known Tajikistan has very few gas and oil (Petrov and Leonidova, 2001). There are relatively rich reserves of the coal, but is less utilized because of lack of good roads in the mountains and/or modem equipment for production. In this paper data on hydro and wind power resources of Tajikistan, Kyrgyzstan and Pakistan are presented. As an example, the

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project for control of water resources at mutual supplementary wind, hydropower and photovoltaic systems of Tajikistan is discussed.

2. Hydro power resources

Table 1 shows hydro power resources of Central Asian countries (Petrov and Leonidova, 2001). From the point of RER, in particular, hydropower resources, Tajikistan is rich as compared with non-RER. Concerning hydropower Tajikistan occupies the first position in Central Asia, the second in former Soviet Union and the eighth position in the world. Indeed hydro power is the base of centralized power system that provides energy to industry and to the population of urban areas. In Tajikistan, first hydropower plant was constructed in 1936 (Karimov and Karimov, 1998). At present, total installed capacity of hydropower plants is almost 4420 MW, including 378 MW from thermal electric plants (which is only 10% of the hydro power). Hence it is obvious that hydro power plays a dominant role in energy balance of Tajikistan. At the time of Soviet Union, a number of hydropower plants were constructed (Petrov and Leonidova, 2001) (Table 2). At present the Republic continues construction of hydroelectric power stations of 3600 MW in Rogun and 220 MW in Sangtuda-2. Experts have estimated that Tajikistan from the point of technical potentialities and ecological criterion can fulfill country's needs of electric energy and can even export part of it to Iran, Afghanistan and Pakistan, by utilization of its hydraulic power resources only (Petrov and Leonidova, 2001).

3. Combined wind, hydropower and photovoltaic systems for management of water resources

Currently Tajikistan is suffering badly with energy crisis associated primarily with a deficit of traditional energy resources (oil and gas), which adversely affects the industrial potential and the economy as a whole. As mentioned earlier that Tajikistan has huge hydropower resources. Wind energy potential is almost never used on industrial scale, and regulation of water is inadequate for efficient irrigation and energy utilization. In the region, a conflict of interests for irrigation and energy generation is increasing, that is between the demands for water for irrigation in the summer and energy in the winter that can be solved by saving water in the reservoirs during the summer (Solar Electricity, 2000). The estimates of potential of hydropower and wind resources of Tajikistan are sufficient not only for the needs of the country but for the export of electric power to neighboring countries as well (Karimov et al., 1995). Integrated and sustainable use of these resources can meet not only the needs of the Republic, but will also allow exporting cheap and clean energy to other countries for their improved environmental situation in the region (Anon., 2011; Anon., 2008).

However, for effective and mutual supplementary use of energy from different resources, proper monitoring and assessment, proper data collection is needed. A preliminary assessment has confirmed that there is sufficient wind potential in several areas of the country, with much stronger winds in the winter during the peak demand for electricity. Preliminary calculations based on the preliminary data show that the medium-term objectives for the installation of wind power plants of total power of 500 MW (less than 15% of the total installed hydropower plants in the country today) would save annually about 1.2 cubic kilometers of water in the Norak hydropower plant (11.4% of the total volume of the Norak reservoir).

Fig. 1 shows hydropower, wind power and consumption of electric power in Tajikistan during one year. Maximum hydropower with minimum wind power and vice versa is observed in summer and winter respectively, with maximum electric power consumption in winter. It means utilization of wind power, especially in winter time, will allow saving of some amount of water in reservoir for irrigation in summer period. It can be concluded that at present Tajikistan can export electric power in summer time, whereas it has to import some amount of energy in winter time or utilize the water of reservoirs for the production of electric power for its needs. But this scenario would have negative response to Uzbekistan and Kazakhstan due to flood of the lands in winter and shortage of water for irrigation in summer.

Therefore by the government of the Republic of Tajikistan and Academy of Sciences in collaboration with government of the USA, the project is discussed for the management of water resources of Central Asia by combined utilization of wind and hydropower. In the project's framework, assessment of the data will be made on mutual supplementary wind- hydropower potentials for effective management of the water resources of the country. In practice, a scientific and technical base will be created for the installation of powerful wind power systems in the regions where wind energy potential is sufficient for practical utilization. By the completion of this project, the utilization of water for irrigation and electricity generation will be improved significantly. It is known that the cost of electricity of wind power plants is higher than generated by hydropower plants. However, Tajikistan has to use wind power potential to solve the problems of dry years and diversify its energy resources and to manage the water resources. The potential of country's wind energy is assessed as 1.0 GW (Akhmedov et al., 2010).

When the melting of glaciers by 2030 will have a major impact on reducing the level of the river, and when the total installed hydropower will reach about 10 GW, the goal to get 300–500 MW of wind power in the next few years is now quite realistic in view of existing 4420 GW of hydropower installed capacity. Completion of this project will provide data and necessary scientific and technological base. This in future will allow construction and commissioning of wind power systems with a capacity of 30–100 MW and more. This will assist in filling the power balance of the country in winter, saving water in reservoirs, especially in drought years and getting of work experience for the integration of electricity generated by wind and hydroelectric power in the unified energy system of the country.

A preliminary assessment allows analyzing monthly data on the wind power potential for areas of Tajikistan including Khujand, Shurabad and Muminabad, where in winter an average wind velocity is almost 5–6 ms^{-1}. Wind energy component can reach more than 10% of the hydropower component in energy balance of the Tajikistan.

Near the city of Khujand there are several places where the exhausted uranium mines (tails depositaries) are situated. These

Table 1
Hydro power resources of central Asian countries.

Sr #	Country	Hydro power resources (TWh)			
		Potential	Technical	Economical	utilized
1	Uzbekistan	88	27.4	15	6.8
2	Kyrgyzstan	143	73	32	9.5
3	Tajikistan	300	144	88	15.8
4	Turkmenistan	24	5.8	5.8	–
5	Kazakhstan (south)	20	20	10	1.7
6	Afghanistan	10	10	6	0.6
	Total	585	280.2	156.8	34.4

Table 2
Main hydropower plants of Tajikistan.

Sr. #	Details
1	Norak (3000 MW, height of dam is 300 m, constructed in 1960–1980)
2	Baipaza (600 MW).
3	Golovnaya (240 MW)
4	Kayarkkum (126 MW)
5	Sangtuda-1 (670 MW, constructed in 2009)
6	Sangtuda-2 (220 MW, constructing)
7	Rogun (3600 MW, height of dam is 355 m, constructing)