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Review

Water development for hydroelectric in southeastern Anatolia project (GAP) in Turkey

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ABSTRACT

Southeastern Anatolia Project (GAP) region in Turkey is rich in water for irrigation and hydroelectric power. The Euphrates and Tigris rivers represent over 28% of the nation's water supply by rivers, and the economically irrigable areas in the region make up 20% of those for the entry country. On the other hand, 85% of the total hydro capacity in operation has been developed by DSI, corresponding to 9931 MW (49 hydro plants) and 35,795 GWh/year respectively. The largest and most comprehensive regional development project ever implemented by DSI in Turkey is "The Southeast Anatolian (GAP) Project", which is located in the region of Southeast Anatolia on the Euprates and Tigris rivers and their tributaries, which originate in Turkey. The energy potential of the Tigris and Euphrates is estimated as 12,000 GWh and 35,000 GWh, respectively. These two rivers constitute 10% and 30% of the total hydroelectric energy potential. The GAP region will be an important electric power producer with 1000 MW installed capacity from the Karakaya dam, 2400 MW installed capacity from the Atatürk dam and 1360 MW installed capacity from the Keban dam. The GAP region has a 22% share of the country's total hydroelectric potential, with plans for 22 dams and 19 hydroelectric power plants. Once completed, 27 billion kWh of electricity will be generated annually.

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1. Introduction

By the year 2010, Turkey is planning to exploit two-thirds of its hydropower potential, aiming to increase hydro-production to about 75,000 GWh/yr. By 2020 this will rise to 100,000 GWh/yr, and by 2030 it could be 140,000 GWh/yr (DSI, 2006). On the other hand, there are 436 sites available for hydroelectric plant construction, distributed on 26 main river zones. The total gross potential and total energy production capacity of these sites are nearly 50 GW and 112 TWh/yr, respectively. As an average, 30% of the total gross potential may be economically exploitable. At present, only about 18% of the total hydroelectric power potential is exploited. The national development plan aims to harvest all of the hydroelectric potential by 2010 [1–3].

Water resources development around the world has taken many different forms and directions since the dawn of civilization. Humans have long sought ways of capturing, storing, cleaning, and redirecting freshwater resources in efforts to reduce their vulnerability to irregular river flows and unpredictable rainfall. Early agricultural civilizations formed in regions where rainfall and runoff could be easily and reliably tapped. The first irrigation canals permitted farmers to grow crops in drier and drier regions and permitted longer growing seasons. The growth of cities required advances in the sciences of civil engineering and hydrology as water supplies had to be brought from increasingly distant sources [4–7].

The southeastern Anatolia project (GAP) is one of the largest power generating, irrigation, and development projects of its kind in the world, covering 3 million ha of agricultural land. This is over 10% of the cultivable land in Turkey, and the land to be irrigated is more than half the presently irrigated area in Turkey. GAP is an integrated development project. It is expected to affect the entire structure of the GAP region (Fig. 1) in its economic, social and cultural dimensions through a process of transformations to be triggered by agricultural modernization. It is envisaged as the means of bridging the gap between the southeastern region and the more advanced areas of Turkey and of increasing the welfare of the region. The GAP project on the Euphrates and Tigris rivers encompasses 22 dams and 19 hydroelectric power plants and irrigation schemes on an area extending over 1.7 million ha. The total cost of the project is 32 billion US$. The total installed capacity of its power plants is 7476 MW, which means an annual production of 27 billion kWh [7–9].

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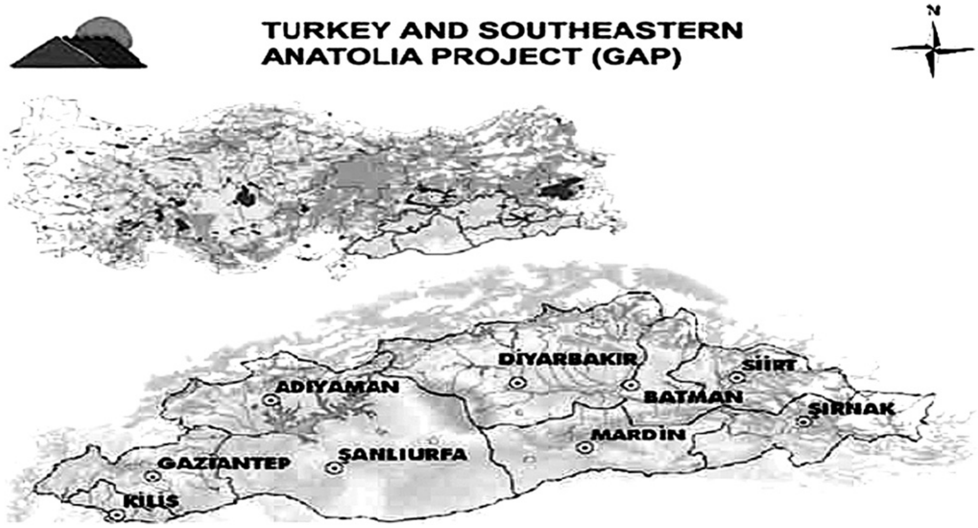

Fig. 1. GAP region [10].

The Atatürk Dam has been important in the completion of the lower Euphrates project and even the entire GAP project, for it is the water source of the four projects aimed at irrigation of 852,781 ha. The total area to be irrigated from the Atatürk Dam will reach approximately 1,000,000 ha. The Atatürk Dam, which is the sixth largest volume dam (48.7 billion m^3) in the world, is installed in Urfa province by the State Hydraulic Works (DSI). The type of dam is rock packed, with 169 m height from the river bed and 1664 m long crest. The body packed volume of the dam is 84.5 million m^3. The Atatürk Dam has eight units with 300 MW installed capacity of each unit, and the mean value of electrical energy production is 8.5 billion kW h/yr.

The GAP will play an important role in the development of Turkey's energy and agriculture sector in the near future. For this reason, it is suitable to examine the general structure of this project and its effects. The GAP project is one of the largest power generating, irrigation, and development projects of its kind in the world, covering 3 million ha of agricultural land. This is over 10% of the cultivable land in Turkey; the land to be irrigated is more than half of the presently irrigated area in Turkey. In this paper, general structure of the project, the natural resources and the hydroelectrical energy generation potential of the GAP is aimed to be evaluated as well as investigating the physical characteristics of the water source systems of the region in relation to planning-application problems [6,9–12].

2. Water development and power plant for hydroelectric

Hydroelectric power plants capture the energy released by water falling through a vertical distance, and transform this energy into useful electricity. In general, falling water is channeled through a turbine which converts the water's energy into mechanical power. The rotation of the water turbines is transferred to a generator which produces electricity. The amount of electricity which can be generated at a hydroelectric plant is dependant upon two factors. These factors are the vertical distance through which the water falls, called the "head", and the flow rate, measured as volume per unit time. The electricity produced is proportional to the product of the head and the rate of flow. The following is an equation which may be used to roughly determine the amount of electricity which can be generated by a potential hydroelectric power site [13,14]:

$$\text{Power(kW)} = 5.9 \times \text{Flow} \times \text{Head} \qquad (1)$$

In this equation, flow is measured in cubic meters per second and head is measured in meters. Based on the facts presented above, hydroelectric power plants can generally be divided into two categories.

"High head" power plants are the most common and generally utilize a dam to store water at an increased elevation. Heads for this type of power plant may be greater than 1000 m. High head plants with storage are very valuable to electric utilities because they can be quickly adjusted to meet the electrical demand on a distribution system.

"Low head" hydroelectric plants are power plants which generally utilize heads of only a few meters or less. Power plants of this type may utilize a low dam or weir to channel water, or no dam and simply use the "run of the river". This type is called as small hydropower plant (SHP).

3. Global hydropower and sustainable development in developing countries

There is about 700 GW of hydro capacity in operation worldwide, generating 2740 TWh in 2000 (about 19% of the world's electricity production). About half of this capacity and generation is in Europe and North America with Europe the largest at 32% of total hydro use and North America at 23% of the total. However, this proportion is declining as Asia and Latin America commission large amounts of new hydro capacity. On the other hand, small, mini and micro hydro plants also play a key role in many countries for rural electrification. An estimated 300 million people in China, for example, depend on small hydro [3,15].

Until recent years there has been less than 100 GWh/year of new hydro capacity under construction at any one time, equivalent to less than 15% of the capacity in operation. The figure has now risen, reflecting China's vast construction program, which includes the 18.2 GW Three Gorges Project, now in its second phase of construction. Most new hydro capacity is under construction in Asia and South America. China has by far the most, with about 50 GW under way. Brazil has largest resources in world (800,000 GWh/year) of economically exploitable capacity and

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