WATER MANAGEMENT AND HYDROPOWER ASPECTS IN TURKEY

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ABSTRACT

Although Turkey has an adequate amount of water in general, it is not always in the right place at the right time to meet present and anticipated needs. As regards hydrology, Turkey is divided into 26 drainage basins. The rivers in general have irregular regimes, and natural flows cannot be taken directly as usable resources. The average annual precipitation, evaporation and surface runoff geographically vary greatly and Turkey has 665,000 ha of inland waters, excluding rivers and small streams. Most of these are very suitable for hydropower plants especially small hydropower plants (SHPP's). On the other hand, there are 200 natural lakes, with a total area of 500,000 ha, and 775 dam lakes and ponds with a total surface area of 165,000 ha. It is accepted that all of the economically irrigable land will be irrigated with irrigation schemes constructed by the year 2030 and water consumption for irrigation will be 71.5 billion m^3. Hence, while its share in the total consumption was 75% in 1999, the share of irrigation water in the total water consumption will be decreased to 65% by the year 2030, through the utilization of modern irrigation techniques. 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. This paper deals with water management and hydropower aspects in Turkey.

Keywords: Water management, irrigation, hydropower, small hydropower (SHP), Southeastern Anatolia Project (GAP).

1. Introduction

Hydropower contributes one-fifth of the world's power generation. In fact, it provides the majority of supply in 55 countries. For several countries, hydropower is the only domestic energy resource. Its present role in electricity generation is therefore substantially greater than any other renewable energy technology, and the remaining potential, especially in the less developed countries such as Turkey, is vast. While it is not a panacea, in that it is restricted to sites with available water and appropriate geomorphology, hydropower's flexibility and proven technology sets it apart from other renewable energy sources (Yuksel, 2008; Kaygusuz, 2002; Kaygusuz, 2004).

When water resources are not available to replenish reservoirs by natural inflow, pumped-storage schemes have been developed to assist in the storage of energy from other generation sources. Therefore, hydropower can substantially improve efficiency in a mixed power system, reducing emissions from fossil-fuel power plants, and backing up intermittent sources such as wind power (IEA, 2002; IHA, 2003).

The hydropower industry is closely linked to both water management and renewable energy production, and so has a unique role to play in contributing to sustainable development in a world where billions of people lack access to safe drinking water and adequate energy supplies. On the other hand, approximately 1.6 billion people have no access to electricity and about 1.1

billion are without adequate water supply. However, resources for hydropower development are widely spread around the world. Potential exists in about 150 countries and about 70% of the economically feasible potential remains to be developed-mostly in developing countries where the needs are most urgent (IEA, 2002; IHA, 2003; WEC, 2001).

2. Water and hydroenergy resources in Turkey

This average annual precipitation corresponds to an average of 501 km^3 (501 billion m^3) of water per year. While 274 km^3 of this quantity returns to the atmosphere through evaporation-transpiration, 69 km^3 feeds the aquifers through infiltration from the surface. Thus, the average annual surface water potential is 186 km^3, of which 158 km^3 comes from surface runoff and 28 km^3 of groundwater feeds the rivers. With a surface run-off of 7 km^3 volume coming from the neighbouring countries, the total surface run-off within the country reaches 193 km^3. However, from the economic and technical points of view, the average exploitable water potential of the country is 110 km^3 per year (DIE, 2004; DSI, 2004).

In view of the considerable variation in runoff in terms of seasons, years and regions, it is necessary for the major rivers in Turkey to have water storage facilities, to allow for the use of the water when it is necessary. Consequently, priority has always been given to the construction of water-storage facilities. Significant progress has taken place in the construction of dams throughout the 48 years that have elapsed since the establishment of the State Hydraulic Works (DSI) (DSI, 2004).

With the projects developed primarily by DSI and other institutions engaged in water resources development, water consumption in Turkey reached 39.3 billion m^3 by 2000, corresponding to only 36% of the economically exploitable water resources. During water consumption estimates on a sectorial basis, it is accepted that all of the economically irrigable land will be irrigated with irrigation schemes constructed by the year 2030 and water consumption for irrigation will be 71.5 billion m^3. Hence, while its share in the total consumption was 75% in 1999, the share of irrigation water in the total water consumption will be decreased to 65% by the year 2030, through the utilization of modern irrigation techniques (MENR, 2006).

Turkey has a wide variety of conventional and renewable energy resources including lignite, hard coal, asphaltite, bituminous shale, oil, natural gas, hydro, biomass, geothermal, wind and solar (see Tables 1 and 2). However, most of these are of inadequate quality and quantity. Each of its coal, geothermal and hydro reserves is estimated to be around 1% of world reserves, and its oil and natural gas reserves are negligible compared with the world total (MENR, 2006; IEA, 2005; IHA, 2006; TEDAS, 2003; TEIAS, 2005). Turkey’s national energy resources consist mainly of hydraulic (126 TWh/year), Approximately 126 TWh of hydropower potential corresponds to 35,000 MW of generation capacity.

Table 1: Primary Energy Production (MENR, 2006; IEA, 2005).

	1990	1995	2000	2002	2004
Hard Coal (Kt)	2745	2248	2259	2245	1946
Lignite (Kt)	44407	52758	60854	51048	43709
Asphaltite (Kt)	276	67	22	5	722
Oil (Kt)	3717	3516	2749	2420	2276
Natural Gas (Million m^3)	212	182	639	407	708
Hydro (GWh)	23148	35541	30879	33684	46084
Geothermal- Elec. (GWh)	80	86	76	105	93
Geothermal- Heat (Ktoe)	364	437	648	730	811
Wind (GWh)			33	48	58
Solar (Ktoe)	28	143	262	318	375
Wood (Kt)	17870	18374	16938	15614	14393
Dung (Kt)	8030	6765	5981	5609	5278
TOTAL (Kt)	25478	26719	26855	24569	24397

Table 2: Primary Energy Consumption (MENR, 2006; IEA, 2005).

	1990	1995	2000	2002	2004
Hard Coal (Kt)	8191	8548	15393	13756	18904
Lignite (Kt)	45891	52405	64384	51446	44823
Asphaltite (Kt)	287	66	22	5	722
Oil (Kt)	22700	27918	31072	29624	31729
Natural Gas (mcm)	3418	6937	15086	17723	22446
Hydro (GWh)	23148	35541	30879	33684	46084
Geothermal- Elec.(GWh)	80	86	76	105	93
Geothermal- Heat (Ktoe)	364	437	648	730	811
Wind (GWh)			33	48	58
Solar (Ktoe)	28	143	262	318	375
Wood (Kt)	17870	18374	16938	15614	14393
Dung (Kt)	8030	6765	5981	5609	5278
Electricity Import (GWh)	-731	-696	3354	3153	-681
Secondary Coal Import (Ktoe)	453	1024	2184	2310	2209
TOTAL (Kt)	52987	63679	81251	78403	87819
Per Capita Consumption (Koe)	944	1031	1205	1126	1231

3. Water management and hydropower in Turkey

Hydroelectric power plants go back some 90 years and they supply about 34% of the electricity produced in Turkey. The first production began with a 60 kW hydro plant in Tarsus, which was used only for providing lights during the initial years of the Republic of Turkey. The installed capacity taken over by the Republic was 29,664 kW, and the electricity was available only in Istanbul, Izmir, Tarsus and Adapazarı. With the development of industry, usage of electrical energy other than for lighting started in 1930 and large industrial establishments began trying to produce their own electricity (Ozgobek and Timucin, 2002; Adiguzel and Tutus, 2002; Altinbilek and Cakmak, 2001; Altinbilek, 2002; Cakmak, 1998).

Water projects were initiated by the Ministry of Public Works under the leadership of Atatürk in 1932. The Electrical Power Resources Planning and Survey Administration (EIE) was then established in 1935 to define Turkey’s energy demand, carrying out surveys and investigations to develop the hydroelectric potential of water resources and other energy resources. The important projects of that period were Seyhan, Sarıyer, Hirfanlı, Kesikköprü, Demirköprü and Kemer dams and hydro plants. There were altogether 28 hydro plants, sharing 3.2% of the total energy production, by 1940. Etibank and the Bank of the Provinces were involved in the construction of small hydropower plants and the electrification of villages and towns (Altinbilek and Cakmak, 2001; Altinbilek, 2002; Cakmak, 1998; Altinbilek *et al*., 1999).

It is estimated that there is considerable small hydropower (SHP) potential in Turkey. DSI has started a pre-investigation study on "The Place of Small HEPPs Within Estimated Hydroelectric Potential". These studies conclude that an additional technical hydroelectric energy potential of 57 TWh/year could be utilizable. 38 TWh/year of hydroelectric energy potential, corresponding to two-thirds of this additional potential, has been estimated to be economically utilizable, so the total economically utilizable hydroelectric potential of Turkey will reach 164 TWh/year (MENR, 2006; Akkaya, 1999; Yuksek *et al*., 2006; Kaygusuz, 2002; EIE, 2004; Kaygusuz, 1999).

Approximately 50% of the additional potential of 38 TWh (that is, 19 TWh) could be realized as small HEPPs (hydroelectric power plants), with installed capacities of less than 10 MW. The share of SHP potential in the total, which is 3% at present, would be 14%. On the other hand, in accordance with the results obtained from the pre-evaluation study, about 15% of the increase in 126 TWh/year exploitable energy potential might be achieved by developing additional SHP potential. However, this study gives only rough results about the additional SHP potential of the country and the potential must be evaluated more precisely, with comprehensive master plan studies for each hydrological basin (MENR, 2006; Akkaya, 1999; Yuksek *et al*., 2006).

On the other hand, 85% of the total hydro capacity in operation has been developed by DSI, corresponding to 9,931 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 Euphrates and Tigris Rivers and their tributaries, which originate in Turkey (Kaygusuz, 1999; Kaygusuz, 2001; Kaygusuz, 2002; Ozturk and Kincay, 2004; Yuksel, 2007; Yuksel, 2006).

4. Conclusions

Hydropower has an extensive list of positive characteristics. In addition to power generation and efficiency, it has advantages such as flood protection, flow regulation, multiple use, fossil fuel avoidance, a long depreciation period, revenue by an adequate electricity rate, and low operating-maintenance-replacement costs. In addition, hydro plants are often superior to other power plants from the standpoint of socio-economic and environmental considerations. The environmental impacts of hydropower plants are at the lowest level compared with the other alternative resources.

In view of the low operational costs of hydropower, related to not having any fuel expense, hydro plants can easily fit load demand, while having a long economic life and low environmental impacts compared with alternative energy resources. Additionally, hydro plants with large reservoirs have multipurpose benefits and profitability, such as flood protection, storing water for domestic water supply, industry and farms, fisheries, navigation, access roads and the potential for a previously inaccessible and remote area to develop economical.

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