Chapter

Hydro Energy Potential for Electricity Generating on Selected Regions in Turkey

Ibrahim Yuksel, Omer Yuksek and Hasan Arman

Abstract

The aim of this chapter is to provide that hydroelectric energy production in Sakarya and Eastern Black Sea Basins which are selected as pilot region in Turkey. Hydroelectric energy has an important place in energy sector is generated from 26 main Basins in Turkey. Sakarya and Eastern Black Sea Basins are very important water resource in Turkey. In this study, hydro energy potential for electricity generating has been investigated in Turkey and hydro energy potential determined for the selected small streams in the Sakarya and Eastern Black Sea Basins by using hydro energy calculating methods.

Keywords: hydropower, energy potential, electricity generation, Sakarya Basin, Eastern Black Sea Basin, Turkey

1. Introduction

The Energy Market Regulatory Agency (EMRA) has license fee exemption for renewable energy investors and the Turkish Electricity Trading Company, TETAS, can provide buying guarantees to renewable energy, further supporting inward investment.

In Turkey, present and future installed electricity capacity by energy sources is given in the **Table 1**. According to the projection, the share of hydro capacity will be

Energy source	2010	2012	2014	2016	2018	2020
Lignite	8280	8280	8280	8280	8280	8280
Hard coal	560	560	560	560	560	560
Imported coal	1840	3470	4680	4690	4690	4690
Natural gas	14,840	17,560	18,400	18,400	18,400	18,400
Geothermal	90	90	90	90	90	90
Fuel oil	1900	1900	1900	1900	1900	1900
Other	29,382	33,920	35,970	35,980	35,980	35,980
Hydropower	16,393	19,880	19,880	21,094	21,094	21,112
Total (MW)	45,255	53,320	55,370	56,594	56,594	56,612

Table 1.
Present and future installed electricity capacity by energy sources (MW) in Turkey.

Renewable energy sources	2000	2005	2010	2015	2020
Primary energy supply					
Hydropower (ktoe)	2656	4067	4903	7060	9419
Geothermal, solar and wind (ktoe)	978	1683	2896	4242	6397
Biomass and waste (ktoe)	6457	5325	4416	4001	3925
Renewable energy production (ktoe)	10,091	11,074	12,215	15,303	19,741
Share of total domestic production (%)	38	48	33	29	30
Share of TPES (%)	12	12	10	9	9
Generation					
Hydropower (GWh)	30,879	47,287	57,009	82,095	109,524
Geothermal, solar and wind (GWh)	109	490	5274	7020	8766
Renewable energy generation (GWh)	30,988	47,777	62,283	89,115	118,290
Share of total generation (%)	25	29	26	25	25
Total final consumption					
Geothermal, solar and wind (ktoe)	910	1385	2145	3341	5346
Biomass and waste (ktoe)	6457	5325	4416	4001	3925
Renewable total consumption (ktoe)	7367	6710	6561	7342	9271
Share of total final consumption (%)	12	10	7	6	6

Table 2.
Renewable energy supply in Turkey.

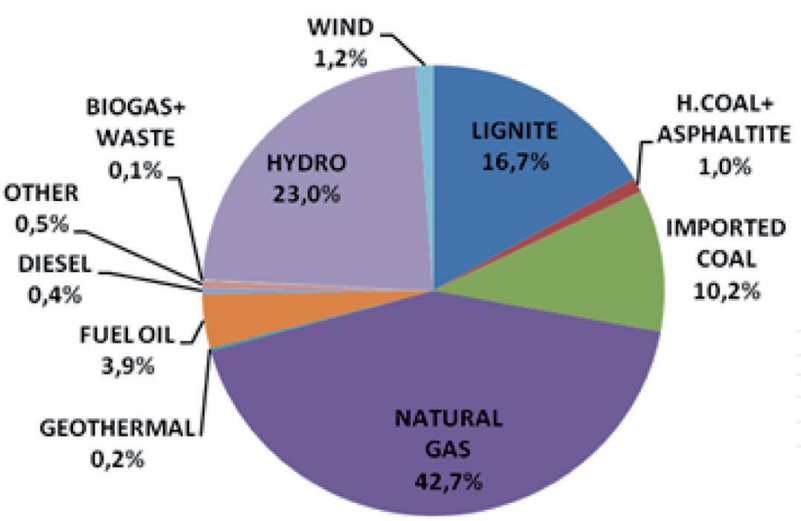

Figure 1.
Share of sources in electricity generation in 2020.

highest with 37.4% and share of natural gas will be 32.6%. Renewable energy supply for at the present and in the future in Turkey is given in the **Table 2** [1–7] and the hare of sources in electricity generation in 2020 is given ın the **Figure 1**.

2. Hydropower capacity and hydropower development in Turkey

In the last decade a lot of dams and small hydropower have been planned to build in Turkey in Eastern Black Sea and Sakarya Basins also. Most of them have been

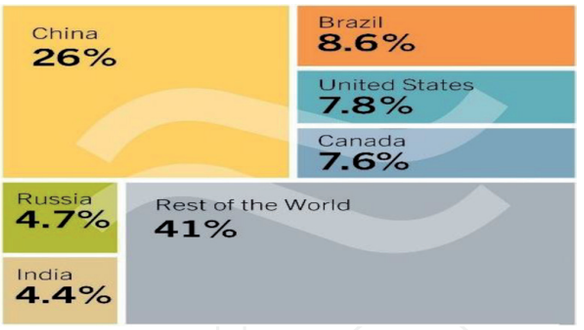

Figure 2.
Hydropower global capacity, shares of top six countries, 2013.

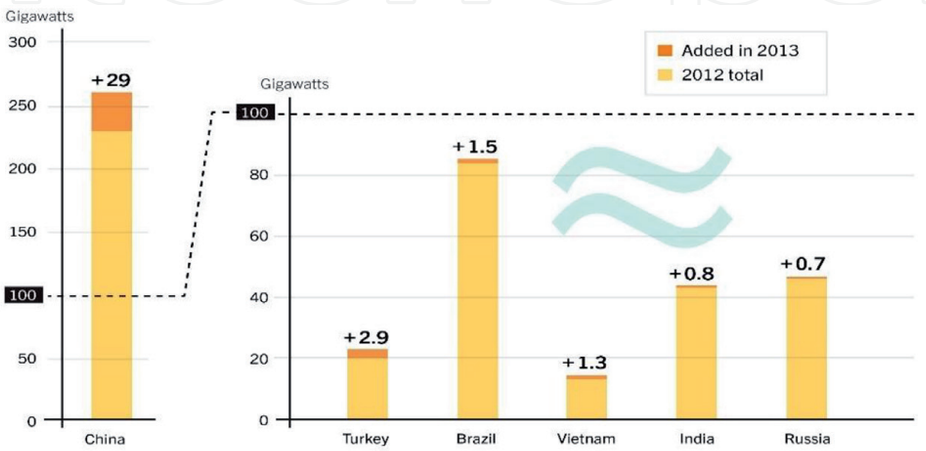

Figure 3.
Hydropower capacity and additions, top six countries for capacity added, 2013.

already completed (for example Deriner Dam 669.60 MV in Artvin) and others under construction (for example Yusufeli Dam 558 MV in Yusufeli) in the eastern Black Sea region. Similarly, Adasu Small Hydropower (10 MV) has been completed and Akçay Dam (12 MV) under construction in Pamukova in Sakarya Basin.

On the other hand, in the last two decades a lot of dams and small hydropower (SHP) either completed or under construction in Turkey. State Hydraulic Works (DSI) provided equipment for the 140 MW Kigi project in Turkey, including three 46.6 MW turbines with pre-turbine gate valves, three generators of the same capacity, switchgear, and all other equipment for the turbine hall [8].

Figures 2 and **3** show hydropower global capacity, shares of top six countries and hydropower capacity and additions, top six countries for capacity added, 2013 respectively [8, 9].

3. Calculation method of hydroelectric potential

There are different methods for calculating hydroelectric energy. Since the amount of energy depends mostly on the water drop and water discharge values it is decided to use the method which is mentioned from some literatures [10, 11]. The method and it equations as follows:

$$N = \gamma * H * Q \tag{1}$$

The equation, $N = \gamma^*H^*Q$, $N = 9.81^*H^*Q^*$ ɳ (ɳ = 0.85–0.92) can be written for N and ɳ is 0.85 the N is calculated as:

$$N = 8 * H * Q \quad (2)$$

and then E is calculated as:

$$E = N * 24 * 365 \quad (3)$$

In these equations:

N = Power (tm/s), (1 tm/s= 9.81 kW = 13.3 HP) and it goes to (kW, MV, GW)
γ = Specific weight (t/m^3)
H = Water drop (head of water) (m)
Q =Water discharge (m^3/s)
E = Energy value of water resource (kWh, MWh, GWh)

4. Hydro energy potential for electricity generating on Sakarya and Eastern Black Sea Basins

4.1 Water resources and hydro energy capacity in Sakarya and Eastern Black Sea Basins

Out of 26 main basins, Sakarya and Eastern Black Sea Basins are very important about hydro energy potential in Turkey.

In 2016, Sakarya and Eastern Black Sea Basins have 63.358 km^2 and 22.845 km^2 area and 5.16 km^3 and 16.46 km^3 annual average flow respectively.

In this study, some streams which are observed their water discharge and the others hydraulics and hydrological characteristic were selected in the Sakarya and Eastern Black Sea Basins [12, 13].

When considered the alternative energy resources, hydroelectric generation is not generally achieved in Turkey, especially in Sakarya and Eastern Black Sea Basins. However, with some laws and regulations enacted, in many activities and opportunities such as construction, production and distribution related to investments carried out exclusively by the Turkish Government, but private sectors have not used enough these opportunities yet. Therefore, by using these facilities well, it will be possible for the private sector to close the energy gap in Turkey or to minimize it by evaluating the river resources in the region [14]. In this study, some small streams have been selected and their hydro energy potential determined for Sakarya and Eastern Black Sea Basins in Turkey.

4.2 Hydroelectric values for selected small streams in the Sakarya and Eastern Black Sea Basins

There are three types of potential which are gross (theoretical) potential, technical potential and economical potential [12, 15, 16].

Economical potential in generally depends on some geological and technical conditions such as geographical structure of basin, technical team and equipment facilities etc. To calculate of hydropower potential for selected streams in the Sakarya and Eastern Black Sea Basins the equations 1, 2 and 3 are used.

Hydroelectric Power (N) and hydroelectric energy (E) have been calculated by using this method. Hydroelectric power and hydroelectric energy values for selected streams in the Sakarya and Eastern Black Sea Basins are given in the **Tables 3** and **4** respectively.

Stream and station name	Water discharge (Q), m^3/s	Water drop (head of water) (H), m	Hydroelectric power (kW)	Hydroelectric energy (GWh)
Sakarya River - Dogancay	121	41	4217	364
Kocasu - Rustumkoy	17.9	198	3013	260
Sakarya River - Aktas	7.19	837	5115	442
Aladağ Stream - Karakoy	13.3	505	5709	493
Mudurnu Stream - Dokurcun	7.75	286	1884	163
Total			19,938	1722

Table 3.
Hydroelectric power and hydroelectric values for selected streams in the Sakarya Basin.

Name of selected small stream	Average water discharge (m^3/s)	Average water drop (altitude) (m)	Hydroelectric power (kW)	Hydroelectric energy (GWh)
Iskefiye Stream	1.3	535	5.564	48.74
Sana Stream	1.5	455	5.460	47.83
Orta Stream	1.05	285	2.394	20.97
Horyan Stream	1.12	230	2.061	18.05
Canakci Stream	2.36	405	7.646	66.98
Yanbolu Stream	4.90	60	2.352	20.60
Kalyan Stream	2.45	135	2.646	23.18
Fol Stream	2.91	155	3.608	31.61
Kucuk Stream	2.34	110	2.059	18.04
Durana Stream	1.71	90	1.231	10.79
Kadiralak Stream	2.90	135	3.132	27.44
Manahoz Stream	4.98	65	2.590	22.68
Baltaci Stream.	5.72	75	3.432	30.06
Altıntas Stream	4.11	95	3.124	27.36
Acisu Stream	1.56	155	1.934	16.95
Akhisar Stream	1.60	105	1.344	11.77
Solakli Stream	2.13	105	1.789	15.67
Holo Stream	2.65	95	2.014	17.64
Askaroz Stream	6.26	105	5.258	46.06
Kokasor Stream	4.03	105	3.385	29.65
Pilahoz Stream	2.50	95	1.900	16.64
Potomya Stream	0.84	145	974	8.54
Hako Stream	0.83	105	697	6.11
Hongra Stream.	0.36	105	302	2.65
Buyuk Stream	1.56	105	1.310	11.48
Vanazit Stream.	2.56	70	1.434	12.56

Name of selected small stream	Average water discharge (m^3/s)	Average water drop (altitude) (m)	Hydroelectric power (kW)	Hydroelectric energy (GWh)
Zekere Stream	1.85	105	1.554	13.61
Kizilev Stream	6.34	105	5.326	46.65
Koyunham Stream	1.47	105	1.235	10.82
Baltama Stream	1.76	105	1.478	12.95
Tokmadin Stream	1.28	245	2.509	21.98
Bal Stream	0.67	155	831	7.28
Catalcam Stream	0.89	125	890	7.80
Kirikli Stream	0.80	95	6.08	5.33
Yagli Stream	13.01	55	5.724	50.15
Total			89.798	786.61

Table 4.
Hydroelectric power and hydroelectric values for selected streams in the Eastern Black Sea Basin (some data are from [17]).

5. Conclusion

In this study shows that Turkey has abundant hydropower energy sources and great renewable energy potential and is keen to reduce its dependence on fossil fuels by increasing its use of renewable energy resources. The hydropower sector is a good example of the increasing interest in generation of electricity with renewable resources. It is expected that the Government will call for tenders for hydropower licenses.

It is well known that the environmental impacts of hydro plants are minimal compared with alternative resources. They make use of our renewable "green energy" resource, without causing pollution. It is not enough for governments to support the development of renewable energy technologies. They must also support their commercial application in the country.

On the other hand, hydroelectric facilities are very valuable resources in Sakarya and Eastern Black Sea Basins, which has a great potential due to meteorological, topographic, hydraulics and hydrological conditions. Using this potential, the economic situation of people most of whom are unemployed and poor and live rural areas will be significantly improved.

Since small hydropower plants are river type hydropower plants, small hydropower potential should be used in the country especially in the Sakarya and Eastern Black Sea Basins. Because river type power plants are superior than the other plants, this type plants have not only cost and operational features but also good environmental effects.

List of symbols and abbreviations

E	energy value (kgm)
N	power (kgm/s)
γ	specific weight (kg/m^3)
Q	water discharge (m^3/s)
H	head of water drop (m)
η	efficiency factor of turbine (%)

S	statistic
V	variance
t_i	the number of ties of length (m).
Z	the statistic S is then standardized
d	difference between ranks
n	number of data
R	rank value
S	Sen's slope
x	denotes the variable
i and j	indices
b	median S_k
TWh	terra watt hour
GWh	giga watt hour
MWh	mega watt hour
kW	kilo watt

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