HYDRAULIC ENERGY, RENEWABLES AND ENERGY SITUATION IN TURKEY

ENERGIE HYDROELECTRIQUE, RESSOURCES D'ENERGİES RENOUVELABLES ET SITUATION EN TURQUİE

Akpinar A, Kömürcü Murat İ, Kankal M, Önsoy H & Filiz M.H

Karadeniz Technical University, Civil Engineering Department, Hydraulic Division 61080 Trabzon/ TURKEY, aakpinar@ktu.edu.tr.
mkomurcu@ktu.edu.tr; mkankal@ktu.edu.tr; honsoy@ktu.edu.tr mustafah.filiz@gmail.com

ABSTRACT: The effects on global and environmental air quality of pollutants released into the atmosphere from fossil fuels in power plants provide strong arguments for the development of renewable energy resources. Clean, domestic and renewable energy is commonly accepted as the key for future life, not only for Turkey but also for the world. In this regard, the objective of this paper is to present a review of the energy situation, technical and economical potential and utilization of renewables and compares the hydraulic energy with the other renewable energy, in Turkey. The renewable energy potential of the counter and, their present utilization are evaluated based on the available data. The present paper shows that hydraulic energy is an important renewable energy source for clean, sustainable and cheaper energy source compared some other energy sources used in Turkey, as in the world. Development studies and investments in this sector should be supported increasingly.

Keywords: renewable energy, hydraulic energy, Turkey.

RESUME : En raison des influences négatives environnementales des gaz polluants à la sortie des usines de production d'électricité d'origine du pétrole et du gaz (fossiles), des discussions très importantes dans le domaine des énergies propres et renouvelables ont été commencées dans le monde entier. Ces ressources ne sont pas seulement importantes pour la Turquie, elles sont aussi importantes à analyser dans le monde entier. Donc, cette étude a pour but d'analyser la rentabilité technique et économique des potentiels d'énergies renouvelables du type hydraulique, éolienne, solaire, bioénergie et géothermale dans le domaine de production et de la consommation. Pour cette analyse, nous avons étudié toutes les données disponibles sur ces ressources. Cette étude a montré que, l'énergie hydroélectrique est un potentiel renouvelable très important qui est beaucoup plus propre, renouvelable et économique par rapport aux autres sources d'énergie utilisée en Turquie et dans le monde. Pour cette raison, les recherches dans ce domaine doivent être financées et soutenues par les secteurs concernés.

Mots clés : énergies renouvelables, hydroélectrique, Turquie

INTRODUCTION

The effects on global and environmental air quality of pollutants released into the atmosphere from fossil fuels in power plants provide strong arguments for the development of renewable energy resources. Clean, domestic and renewable energy is commonly accepted as the key for future life, not only for Turkey but also for the world. The consumption of conventional energy (coal, petroleum and natural gas) on one hand results in serious environmental pollution problems, and on the other hand faces with the danger of exhaustion. In order to have a sustainable development in Turkey, it must be enhanced the efficiency of the conventional energy generation and increased the proportion of renewable energy sources in the total energy budget.

In this paper, energy situation in Turkey is analyzed; renewable energy sources including hydraulic energy, biomass energy, solar energy, wind energy and geothermal energy are examined with respect to their potential and current use.

ENERGY SITUATION IN TURKEY

Although Turkey has almost all kinds of energy resources, it is an energy importing country; more than half of the energy requirement has been supplied by imports. Therefore, it seems that if the country wants to supply its demand by domestic resources (such as lignite, hard coal, oil, and natural gas), the transition to renewable energy resources must be realized in a reasonable time period (Kaygusuz & al, 2003). When it is examined energy consumption data of Turkey, it is realized that oil has the biggest share in total primary energy consumption. The high level of dependence on imported petroleum and natural gas is the dominant factor in Turkey's pattern of energy consumption. While the share of petroleum in consumption of commercial primary energy increase 1.12% from 2005 to 2006, the share of natural gas in consumption of commercial primary energy grow 16.8% from 2005 to 2006.

Turkey's primary energy sources include hydropower, geothermal, lignite, hard coal, oil, natural gas, wood, animal and plant wastes, solar and wind energy. In 2006, primary energy production and consumption has reached 26.763 million tons of oil equivalent (Mtoe) and 98.138 Mtoe respectively. Table 1 shows the Turkey's primary energy consumption and production in 2005 and 2006. Fossil fuels provided about 89.3% of the total energy consumption of the year 2006, with oil (33.2%) in first place, followed by coal (29.4%) and natural gas (26.7%). Turkey isn't utilized nuclear energy yet. The Turkish coal sector, which includes hard coal as well as lignite, accounts for nearly one half of the country's total primary energy production, with lignite being the main domestic energy source at 11.545 Mtoe in 2006. The renewables collectively provided 10.7% of the primary energy, mostly in the form of hydropower (about 3.96%), combustible renewables and wastes (5.27%), geothermal (1.1%), and much less by other renewable energy resources (approximately 0.37%).

RENEWABLES

Geothermal Energy

Geothermal energy includes direct uses of heat, electricity production, and geothermal heat pump. Direct applications of geothermal energy can involve a wide variety of end uses, such as space heating and cooling, industry, greenhouses, fish farming, and health spas. The technology, reliability, economics, and environmental acceptability of direst use of geothermal energy have been demonstrated throughout the world.

Turkey has an important place among the richest countries (the first in Europe, seventh in the world) in geothermal potential. Around 1000 hot and mineralized natural self-flowing springs exist in Turkey. The geothermal resources in Turkey can be classified into 3 groups: low temperature fields (< 70 °C), moderate temperature fields (70 °C- 150 °C), and high temperature fields (more than 170 °C). Although they exist all over the country, most of them lie in the Western, North-Western, and Middle Anatolia. The temperature limit is accepted to be 20 °C for balneological purposes. With the exception this, there are 170 geothermal fields with a temperature over 35 °C in Turkey-Aydın-Germencik (232 °C), Denizli-Kızıldere (242 °C), Çanakkale-Tuzla (173 °C), and Aydın-Salavatlı (171 °C) fields—that are suitable for electricity generation. Depending on the use of new technologies, the Manisa-Salihli-Caferbeyli (155 °C), Kütahya-Simav (162 °C), Izmir-Seferihisar (153 °C), Dikili (130 °C), and Denizli-Gölemezli (under search) fields can be used in electricity generation and the others are suitable for direct use [Acar, 2003].

In 2005, geothermal energy use of Turkey amounted to about 119.7 GWh/yr of electricity and 6900.5 GWh/yr for direct use. Turkey is one of the countries with significant potential in geothermal energy. Data accumulated since 1962 show that there may be existed about 4500 MW of geothermal energy usable for electrical power generation in high enthalpy zones [Kaygusuz & Kaygusuz ,2002]. A recent estimate of the geothermal potential of Turkey, gives the total potential resources for direct use in excess of 31500 MWt. These figures for the potential cover both known and unidentified resources. Proven, probable and possible potential of Turkey are given in Table 2 (Fridleifsson, 2001; Altaş, al., 2003, Lund, al., 2005). It is estimated the identified geothermal resources to be 200 MWe for electricity generation (resource temperature in excess of 473 K) and in excess of 3293 MWt heat for direct use (resource temperature lower than 473 K).

Table 3 shows capacity in geothermal utilization in Turkey. Most of the development in the direct use has been in district heating, which now serves 117000 residences (983 MWt), and in individual space heating (74 MWt and 816.8 TJ/yr). A total of 800000 m2 of greenhouses are heated by geothermal fluids (192 MWt and 3633 TJ/yr). Geothermal heated pools used for bathing and swimming account for a capacity of 402 MWt and utilize 12677.4 TJ/yr.

Table 1. Turkey's primary energy production and consumption (Mtoe) (ETKB, 2008)

Energy source	Production (Year)		Consumption (year)		Increase in consumption (2005-2006)
	2005	2006	2005-	2006	%
Fossil fuels	14.425	16.211	79.075	87.586	+ 10.76
Oil	2.395	2.284	32.192	32.551	+ 1.12
Natural gas	0.816	0.839	24.726	28.867	+ 16.75
Coal	11.214	13.088	22.157	26.168	+ 18.10
Nuclear	-	-	-	-	
Renewables	10.124	10.552	10.124	10.552	+ 4.23
Hydro	3.483	3.886	3.483	3.886	+ 11.57
Geothermal heating	0.926	1.081	0.926	1.081	+ 16.74
Solar	0.385	0.403	0.385	0.403	+ 4.68
Wind	0.005	0.011	0.005	0.011	+ 120
Combustible renewable and wastes	5.325	5.171	5.325	5.171	- 2.89
Total	24.549	26.763	89.199	98.138	+ 10.0

Table 2. Status of Turkey's geothermal energy in 2005

	Proven potential **(MW)**	Probable and possible potential **(MW)**
Heating (<473 K)	3293 MWt	31500 MWt
Electricity (>473 K)	200 MWe	4500 MWe

	Capacity (MW_t)	Use (TJ/yr)	Use GWh/yr	Capacity factor
Direct use	1495	24839.9	6900.5	0.53
Electricity	20.4		119.73	

About 120000 tonnes of liquid carbon dioxide and dry ice are produced annually at the Kızıldere power plant. By the year 2010 Turkey aims at having 500 MWe dedicated to electricity generation and 3500 MWt for space heating. Heat pumps are not being used at present, because of the high cost of electricity (Lund & al., 2005).

It is clear that the present use of geothermal energy is a very small fraction of the identified geothermal potential. 4% of geothermal source potential of Turkey is only evaluated up to 2005. When Turkey uses all of the total geothermal potential it can meet 12.7% of the total energy need (heat + electricity) from geothermal energy. There is certainly space for an accelerated use of geothermal energy both for electricity generation and direct use in the near future (Akpınar & al, 2007).

Table 3. Capacity in geothermal utilization in Turkey (TGA, 2008)

Geothermal Utilization	Capacity
District heating	983 MWt
Balneological utilization	402 MWt
Total direct use	1385 MWt
Carbon dioxide production	120000 t/year
Power production	20 MWe (Denizli – Kızıldere) (operating) 10 MWe (Aydın Salavatlı) (operating) 48 MWe (Germencik) (under const.) 6.85 MWe (Denizli – Kızıldere) (under const.)

Biomass Energy

Biomass is the oldest form of renewable energy exploited by mankind, mainly in the form of wood burnt to provide heat and light for domestic and productive activities. The main biomass resources are agricultural residues and wastes (straw, animal manure, etc.), organic fractions of municipal solid waste and refuse, sewage sludge, industrial residues (e.g., from the food and paper industries), short-rotation forests (willow, poplar, eucalyptus), herbaceous lingo-cellulosic crops (miscanthus), sugar crops (sugar beet, sweet sorghum, Jeruselam artichoke), starch crops (maize, wheat), oil crops (rape seed, sunflower), wood wastes (forest residues, wood processing waste, construction residues). In the long term, energy crops could be a very important biomass fuel source. At present, however, wastes (wood, agricultural, municipal or industrial) are the major biomass sources (OECD-IEA, 2003.

Direct burning in Turkey for many years has used fuelwood, animal wastes, agricultural crop residues, and logging wastes. These sources are often called non-commercial energy sources, but in Turkey, fuelwood is a tradable community since it is the primary fuel in rural and urban poor districts. Fuelwood is the fourth largest source of energy in Turkey. Wood is the major source of energy in rural Turkey. An average consumer in a year burns 0.75 m3 fuelwood. The total forests potential of Turkey is around 935 million m^3 with an annual growth of about 28 million m^3.

The total forest area in Turkey occupies 26% of the country's territory. Traditional fuels predominate in rural areas; almost all biomass energy is consumed in the household sector for heating, cleaning, and cooking needs of rural people. The lumber, pulp and paper industries burn their own wood wastes in large furnaces and boilers to supply 60% of the energy needed to run factories. In their homes, Turkish people burn wood in stoves and fireplaces to cook meals and warm their residences. Wood is the primary heating fuel in 6.5 million homes in Turkey (Demirbas, 2004).

Biogas energy is also derived from biomass, which is combusted as a gas comprising primarily methane, the most common constituent of natural gas. Biogas is commonly generated from biomass waste products at sewage treatment plants, solid waste landfills, through forest sector activities, and agricultural operations. Biogas can be produced through a biological process that "digests" the biomass in a chamber with no oxygen, through a chemical process, or through heating in the absence of oxygen. The biomass products are converted to a gaseous fuel. Biogas is then combusted in a boiler to produce steam for power generation through a steam turbine or through a combustion turbine directly. In both instances, under cogeneration applications, the residual heat is used as energy for other applications. In the coming years, these energy sources will play an increasingly significant role for producing green power (Islam et al, 2004). Biogas production potential in Turkey has been estimated at 1.5 to 2 Mtoe but only two small units (in total 5 MW) are in operation and one new facility (1 MW) has been licensed (OECD-IEA; 2005). Around 85% of the total biogas potential is from dung gas, while the remainder comes from landfill gas. The dung gas potential is obtained from 50% sheep, 43% cattle and 7% poultry (Table 4). The use of animal wastes as biofuel is limited because they are mostly used in agriculture as fertilizers.

Table 4. Distribution of biogas potential of Turkey (Ediger et al, 1999]

	Biogas potential (million m^3/year)
Dung gas	3302.85
Cattle (43.103 million tons dung)	1422.39
Sheep (28.303 million tons dung)	1641.58
Poultry (3.063 million tons dung)	238.88
Landfill gas	600.00
Total biogas*	3902.85

Solar Energy

There are two basic categories of technologies that convert sunlight into useful forms of energy. First, solar photovoltaic (PV) modules convert sunlight directly into electricity. Second, solar thermal power systems use focused solar radiation to produce steam, which is then used to turn a turbine producing electricity.

An important part of Turkey is suitable for utilization of solar energy. Turkey is between the 36° and 42° north latitudes. The solar energy potential of Turkey is the equivalent of 1.3 billion tons of oil. The solar thermal capacity is approximately 2640 h/yr and annual solar intensity is 3.6 kWh/m^2 -day. This is sufficient to provide adequate energy for solar thermal applications (Oğulata et al, 2002). The solar radiation and sunshine duration vary between about 240-395 cal/cm2 –day and 4.5-8.5 h/day, respectively (Ediger et al, 1999). Solar energy potential is given in Table 5. The average solar radiation is 309.6 cal/m2 –day and the average sunshine duration is 7.2 h/day. The south-eastern Anatolia and Mediterranean regions are very suitable for solar energy use.

Table 5. Solar energy potential by region (OECD-IEA, 2005, Oğulata et al ,2002)

Region	Solar radiation *cal/cm²(day)*	Total solar energy *kWh/m² (year)*	Sunshine duration	
			h/day	*h/year*
Southeast Anatolia	344.8	1460	8.2	2993
Mediterranean	328.3	1390	8.1	2956
East Anatolia	322.4	1365	7.3	2664
Central Anatolia	310.3	1314	7.2	2628
Aegean	308.0	1304	7.5	2738
Marmara	275.9	1168	6.6	2409
Black Sea	264.5	1120	5.4	1971
Turkey average	309.6		7.2	

There are basically three types of collectors: flat-plate, evacuated-tube, and concentrating. Flat-plate collectors are the most commonly used types. Flat-plate solar collectors used for domestic water heating are widely used and commercially available in Turkey. In 2003, the collector surface area installed in Turkey was 10 million m^2, including both household systems and large-scale use in hotels, industrial activities, etc. Using these collectors for heating contributed 0.35 Mtoe to energy production. Annual collector manufacturing capacity is 1 million m^2. The EIE installed a computer-aided test stand in order to enable the manufacturers to improve the quality and efficiency of the collectors. It used the test stand to help the Turkish Standard Institute to develop new standard for collectors. The EIE has also developed a parabolic solar cooker and has studied the possibility to use vacuum tube solar collectors in heating and cooling (OECD-IEA, 2005).

PVs are one of the fastest growing solar energy technologies. PV devices, commonly called solar cells o r modules, use semiconductor material to directly convert sunlight into electricity (Hepbaşlı & al, 2006). In the area of photovoltaics, in Turkey, the EIE has implemented some small-scale stand-alone systems but also one grid-connected project. In order to investigate the operational properties of PV systems, one stand-alone 1.6 kW peak (kWp) PV system for power generation was installed already in 1985. A 4.8 kWp grid-connected PV system is installed in Didim Training and Research Centre to gain experience about the operating problems of grid-connected systems. Another 1.2 kWp grid-connected PV system was installed in Ankara in 2002 (OECD-IEA, 2005).

Wind Energy

Wind energy, like most terrestrial energy sources, comes from solar energy. Solar radiation emitted by the sun travels through space and strikes the Earth, causing regions of unequal heating over land masses and oceans. This unequal heating produces regions of high and low pressure, creating pressure gradients between these regions. The second law of thermodynamics requires that these gradients be minimized-nature seeks the lowest energy state in order to maximize entropy. This is accomplished by the movement of air from regions of high pressure to regions of low pressure, what it is known as wind. Large-scale winds are caused by the fact that the Earth's surface is heated to a greater degree at the equator than at the poles [Reeves & Beck, 2003].

Turkey has a land surface area of officially 774815 km2 (Hepbaşlı et al, 2004). Surrounded by mountains, its unique geographical character creates a regular and moderate air inflow through its mountainous straits and passages. Its location between the colder European and warmer Asian and African systems also causes a wide variety of temperature and climate difference (GWEC, 2005). All the land area of Turkey is not suitable for the installation of turbines due to a topographic structure. Based on the examination of the wind atlas may be concluded that the regions of Aegean, Marmara, and East-Mediterranean have high wind energy potential. Turkey's total theoretically available potential for wind power is calculated to be around 88000 MW annually. It is also estimated that Turkey has an economically wind power potential of about 10000 MWe (Hepbaşlı et al, 2004]. Turkey has the highest share with 166 TW/year in technical wind energy potential between European countries (Ogulata, 2003).

Annual average wind speed and annual average wind energy potential of various regions of Turkey are shown in Table 6. The annual average wind speeds range from a low of 2.1 m/s in the East Anatolia region to a high of 3.3 m/s in the Marmara region. The most attractive regions for wind energy applications are the Marmara, the southeast Anatolian, and the Aegean regions. These regions are highly suitable for wind power generation, since the wind speed exceeds 3 m/s in most of these areas (Ogulata, 2003).

Table 6. Wind potential of various regions of Turkey

Region	Annual average wind density (W/m^2)	Annual average wind speed (m/s)
Marmara	51.9	3.3
Southeast Anatolia	29.3	2.7
Aegean	23.5	2.6
Mediterranean	21.4	2.5
Black Sea	21.3	2.4
Central Anatolia	20.1	2.5
East Anatolia	13.2	2.1
Turkey average	24.0	2.5

In Turkey, wind energy use has been focusing on grid-connected systems. At present, total installed wind power capacity in operation is 146.25 MW (Table 7) (EIE, 2008); in three power plants in İzmir, with 1.5, 7.2, and 39.2 MW installed capacity; three in Çanakkale, with installed capacity of 10.2, 30.4, and 15.2 MW; two in İstanbul, with installed capacity of 1.2 and 0.85 MW; one in Balıkesir, with an installed capacity of 30 MW; and one in Manisa, with an installed capacity of 10.8 MW.

Table 7. Status of wind energy sector in Turkey

Location of plants	Date of commissioned	Number of turbine	Installed capacity (MW)
İzmir – Çeşme	1998	3	1.50
İzmir – Çeşme	1998	12	7.20
Çanakkale - Bozcaada	2000	17	10.20
İstanbul – Hadımköy	2003	2	1.20
Balıkesir – Bandırma	I/2006	20	30.00
İstanbul – Silivri	II/2006	1	0.85
İzmir – Çeşme	I/2007	49	39.20
Çanakkale – İntepe	I/2007	38	30.40
Manisa – Akhisar	I/2007	6	10.80
Çanakkale – Gelibolu	II/2007	18	15.20
Total installed capacity in operation			146.25
Manisa – Sayalar		38	30.40
Hatay – Samandağ			30.00
İstanbul – G.paşa		12	24.00
İstanbul - Çatalca		20	60.00
Total installed capacity under construction			144.40

Hydropower

There is a general view that hydroelectricity is the renewable energy source par excellence, non-exhaustible, non-polluting, and more economically attractive than other options. And although the number of hydropower plants that can be built is finite, only a third of the sites quantified as economically feasible are tapped. Most renewable sources of energy hydroelectricity generation are capital intensive but have lower operational costs than thermal and nuclear options.

The high initial cost is a serious barrier for its growth in developing countries where most of the untapped economic potential is located (Turkenburg, 2008).

The gross hydroelectric power potential depends on the foreseen development projects of the region. For Turkey, it are estimated as 433-442 TWh/year that is equel to 1% of the total hydropower potential of the world (Table 8) and 14% of European hydropower potential (Kaygusuz, 2002). Technical hydroelectric power potential corresponds to the technically available part of the gross potential. For example a permeable geological formation will promote a decrease in the available potential. It can slightly increase with developing technologic possibilities. Almost half of the gross potential is technically exploitable. The technical hydroelectric potential of Turkey are estimated as 216 TWh/year Economic hydroelectric power potential corresponds to the economically advantageous part of the technical potential, compared with alternative energy resources (Unsal, 2008). Economic hydroelectric power potential of Turkey is 129.9 TWh/yr by the end of February 2006. 35.4% of this potential is in operation while 8.1% and 56.5% of total potential are under construction and in various design level, respectively.

As of February 2006, there were 142 hydro plants in operation. These have a total installed capacity of 12788 MW and an annual average generation capacity of 45930 GWh, amounting to almost 35.4% of the total exploitable potential, which is meeting about 30.6% of the electricity demand in 2004. Hydro plants with an installed capacity of 3197 MW and an annual generation capacity of 10518 GWh, which is almost 8% of the total potential, are under construction. In the future, 565 more hydropower plants will be constructed to exploit the remaining potential of 73459 GWh/year, bringing the total number of hydropower plants to 565 with a total installed capacity of 20667 MW. Those are being designed are divided into four sub-groups and distribution of Turkey hydro power potential according to design level are given in Table 9. As follows: 10752 GWh/yr (8.3%) with final design ready, 26562 GWh/yr (20.4%) with feasibility report ready, 17819 GWh/yr (13.7%) with master plan ready, and 18326 GWh/yr (14.1%) with preliminary report ready.

Table 8. Hydro potential of Turkey compared to world's potential (DSI, 2008a)

Region	Gross Theoretical Hydroelectric Potential (GWh/year)	Technically Feasible Hydroelectric Potential (GWh/year)	Economically Feasible Hydroelectric Potential.(GWh/year)
Africa	4000000	1665000	1000000
Asia	19000000	6800000	3600000
Australia/ Oceania	600000	270000	105000
Europe	3150000	1225000	800000
North & Central America	6000000	1500000	1100000
South America	7400000	2600000	2300000
World	40150000	14060000	8905000
Turkey	433000	216000	129900
Turkey/World	1.07	1.54	1.84

Table 9. Distribution of Turkey hydro power potential according to design level (February 2006) (EIE, 2006).

Status of hydroelectric plants projects	Number of project	Installed capacity (MW)	Total annual hydroelectric energy generation				
			Reliable energy (GWh)	Total energy (GWh)	Ratio (%)	Cumul. energy (GWh)	Ratio (%)
In operation	142	12788	33560	45930	35.4	45930	35.4
Under constr.	40	3197	6358	10518	8.1	56448	43.5
Planned	565	20667	40006	73459	56.5		
Final design ready	14	3556	7089	10752	8.3	67200	51.8
Feasibilty report ready	175	7306	13305	26562	20.4	93762	72.2
Master plan ready	96	5120	10582	7819	3.7	1581	85.9
Preliminary report ready	280	4685	9030	18326	14.1	29907	100.0
Total potential	747	36652	79924	9907	100.0	29907	100.0

Small hydropower is in most cases “run-of-river”; in other words any dam or hydraulic structure is quite small, usually just a weir, and generally little or no water is stored. The civil works purely serve the function of regulating the level of the water at the intake to the hydropower plant. Therefore run-of-river installations do not have the same kinds of adverse effect on the local environment as large hydro. On the other hand, hydropower has various degrees of “smallness”. To date, there is still no internationally agreed definition of “small” hydro; the upper limit varies between 2.5 MW and 25 MW. A maximum of 10 MW is the most widely accepted value worldwide, although the definition in China stands officially at 25 MW. In Turkey, the upper limit is accepted as 50 MW (Yuksek et al, 2006). The distribution of the hydropower plants, which are under design level and in operation, is presented in Table 10 according to their hydro capacity. As can be seen this table, there is 72 installed small hydropower plants (SHPs), which have 172.95 MW of installed capacity, in Turkey. And it is also planned to allocate 278 SHPs with 1086 MW of capacity. Thus, when planned plants are in operation, installed SHP that currently meets 1.47% of total annual energy will able to meet 4.7% of total annual energy.

Table 10. Distribution of under design and existing hydro power plants (HPPs) according to their hydro capacity [EIE, 2006, DSI, 2008b]

	Classif.	Number of HPPs	Total capacity (MW)	Total reliable energy (GWh/year)	Average annual energy (GWh/year)	Percentage of total annual energy
Under Design HPPs	< 10 MW	278	1086	1552	4940	6.72
	10-50 MW	188	4691	9038	18847	25.66
	> 50 MW	99	14890	29415	49672	67.62
	Total	565	20667	40006	73459	100.00
Existing HPPs	< 10 MW	72	172.95	277.00	675.28	1.47
	10-50 MW	32	734.86	1259.80	2758.00	6.00
	> 50 MW	38	11880.40	32023.00	42497.00	92.53
	Total	142	12788.21	33559.80	45930.28	100.00

CONCLUSIONS

It is well known that the consumption of conventional energy sources resulted in serious environmental pollution problems. Apart from that, fossil fuels are also facing the danger of exhaustion. Turkey should increase the proportion of renewable energy sources in the total energy budget because Turkey is an importing country and domestic fossil fuels are limited and the economical condition of the country is not good. The present study shows that there is an important potential to use renewable energy for Turkey. Especially hydraulic, biomass, geothermal, solar, and wind energy seem to be the most interesting domestic and clean energy sources. Therefore, the use of renewable energy resources shows a promising prospect in Turkey in the future as an alternative to the conventional energy. For any of renewable energy technologies to achieve importance, however, there must be supportive government policy. It must be increased and sustained funding for development of these energy sources.

REFERENCES BIBLIOGRAPHIQUES

Acar H. I., 2003, A review of geothermal energy in Turkey. Energy Sources 25 1083-1088.

Akpınar A., Kömürcü M.İ., Önsoy H. and Kaygusuz K., 2007, Status of Geothermal Energy amongst Turkey's Energy Sources. Renewable and Sustainable Energy Reviews doi:10.1016/j.rser.2006.10.016.

Altaş M., Özkan H.F. and Çelebi E., Energy statistics of the year 2002, 2003 Proceedings of Ninth Energy Congress of Turkey, World Energy Council-Turkish National Committee, İstanbul, Turkey, 24-27 September (in Turkish).

Demirbaş A., 2004,The importance of Biomass, Energy Sources 26 361-366.

DSI (General Directorate of State Hydraulic Works), 2008a, From past to present DSİ 1954-2004. Ankara, Turkey (in Turkish)

DSI (General Directorate of State Hydraulic Works)., 2008b, List of Hydro Electric Power Plant Projects. (http://www.dsi.gov.tr/skatablo/Tablo1. htm)

Ediger V.Ş. and Kentel E., 1999, Renewable energy potential as an alternative to fossil fuels in Turkey, Energy Conversion and Management 40 743-755.

EIE(General Directorate of Electrical Power Resources Survey and Development Administration), 2006, Hydro Electric Power Plant Projects Caried out by EIE. February. Ankara, Turkey (in Turkish).

EIE (General Directorate of Electrical Power Resources Survey and Development Administration), 2008, Status of wind energy sector in Turkey. (http://www.eie.gov.tr/turkce/ruzgar /Turkiye _RES.html).

ETKB (Ministry of Energy and Natural Resources), (2008), Energy Statistics. (http://www.enerji.gov.tr/ istatistik.asp).

Fridleifsson I. B., 2001, Geothermal energy for the benefit of the people. Renewable & Sustainable Energy Reviews 5 299-312.

GWEC (Global Wind Energy Council), 2005, Wind Force 12 Report (a blueprint to achieve 12% of the world'd electricity from wind power by 2020).

Hepbaşlı A., Ulgen K. and Eke R., 2004, Solar energy applications in Turkey. Energy Sources 26 551-561.

Hepbaşlı A. and Ozgener O., 2004, A review on the development of wind energy in Turkey, Renewable and Sustainable Energy Reviews 8 257-276.

Islam M., Fartaj A. and Ting D.S.K., 2004, Current utilization and future prospects of emerging renewable energy applications in Canada, Renewable and Sustainable Energy Reviews 8 493-519.

Kaygusuz K.. 2002, Sustainable development of hydroelectric power, Energy Sources 24 803-815.

Kaygusuz K., Kaygusuz A., 2002, Renewable energy and sustainable development in Turkey. Renewable Energy 25 431–453.

Kaygusuz K., Sarı A., 2003, Renewable energy potential and utilization in Turkey. Energy Conversion & Management 44 459–478.

Lund J.W., Freeston D.H., Boyd T.L., 2005, Direct application of geothermal energy: 2005 worldwide review. Geothermics 34 691-727.

OECD-IEA, 2005 (Organisation for Economic Co-operation and Development, International Energy Agency). Energy policies of IEA countries: Turkey Review, Paris, France.

Oğulata R.T., Oğulata S.N., 2002, Solar energy potential in Turkey. Energy Sources 24 1055-1064.

OECD-IEA, 2003, (Organisation for Economic Co-operation and Development, International Energy Agency). Renewables for power generation: status and prospects . Paris, France.

Oğulata R.T., 2003, Energy sector and wind energy potential in Turkey, Renewable and Sustainable Energy Reviews 7 469-484.

Reeves A., Beck F., 2003,Wind Energy for Electric Power, A Renewable Energy Policy Project Issue Brief, Washington, USA.

TGA (Turkish Geothermal Association), 2008, Geothermal energy in Turkey (http://www.Jeoterm aldernegi.org.tr/),.

Turkenburg W.C., Chapter 7: Renewable energy technologies. World energy assessment: energy and the challenge of sustainability. http://stone.undp.org/undpweb/seed/wea/pdfs/chapter14.pdf)

Ünsal İ., 2003,Turkey's hydroelectric potential and energy policies. E-journal of strategy and analysis. http://mimoza.marmara.edu.tr/~ipeker/sunumlar/2003/sunumlar_1/reports/turkey_hydroenergy.pdf)

Yüksek Ö., Kaygusuz K., 2006, Small hydropower plants as a renewable energy source. Energy Sources Part B-Economics Planning and Policy 1 279-290.