Environmental Impacts of Energy Utilization and Renewable Energy Sources in Turkey

Kamil Kaygusuz
Department of Chemistry, Karadeniz Technical University, 61080 Trabzon, Turkey

ABSTRACT

Turkey is an energy importing country, more than half of the energy requirement has been supplied by imports. Domestic oil and lignite reserves are limited and lignites are characterised by high ash, sulfur and moisture content. Due to increasing energy consumption, air pollution is becoming a great environmental concern for future in the country. In this regard, renewable energy resources appear to be the one of the most efficient and effective solutions for sustainable energy development and environmental pollution prevention in Turkey. Turkey's geographical location has several advantages for extensive use of most of these renewable energy sources. Because of this and the fact that it has limited fossil fuel resources, a gradual shift from fossil fuels to renewables seems to be serious and the sole alternative for Turkey. This article presents a review of the present energy situation and sustainability, technical and economical potential of renewable energy sources and future policies for energy sector in Turkey. Throughout the paper several problems relating to energy sources, environment and sustainable development are discussed from both current and future perspectives.

INTRODUCTION

Energy is essential to economic and social development and improved quality of life in Turkey as in other countries. Much of the world's energy, however, is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially. The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption in the country. On the other hand, electricity supply infrastructures in Turkey as in many developing countries are being rapidly expanded as policymakers and investors around the world increasingly recognize electricity's pivotal role in improving living standards and sustaining economic growth. On the contrary, in the coming decades, global environmental issues could significantly affect patterns of energy use around the world as in Turkey. Any future efforts to limit carbon emissions are likely to alter the composition of total energy-related carbon emissions by energy source in the country (Kaygusuz, l999a).

Although Turkey has almost all kinds of energy resources, it is an energy importing

country, since these resources are limited. More than half of the primary energy consumption in the country is met by imports and the share of imports continues to increase each year. Therefore, it seems that, if the country wants to supply its demand by domestic resources (such as lignite, hard coal, oil and natural gas) to renewable energy resources must be realised in a reasonable time period. The total renewable energy production and consumption of are equal to each other, varying between 9.3–10.8 million tonnes of oil equivalent (Mtoe) each for the 1990–1999 period (Table 1). Their share in total energy production varies average between 37 – 40% while in total consumption between 15 – 22% for the same period (TÜSİAD, 1998).

ENERGY PERSPECTIVES

The energy demand of Turkey will be doubled between the years 2000–2010 and will be fourfold between 2000–2025. This rapid increase in demand is due to high economic development rate of Turkey. The estimated amount of investments for the production facilities by the year 2010 is around 45 billion dollars. Transmission and distribution facilities will require additional 10 billion dollar investment in the same period. The government has undertaken measures to attract local and foreign private sector for new investments, and also to transfer operational rights of existing units to private sector for their renewal and efficient operation (TÜSİAD, 1998; WECTNC, 1999).

Turkey is an energy importing country; more than half of the energy requirement has been supplied by imports. Oil has the biggest share in total primary energy consumption. Due to the diversification efforts of energy sources, use of natural gas

Table 1. Primary energy consumption of Turkey during 1990–1999 (Ktoe)

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Non-Renewable										
Hard coal	6491	6844	6803	6671	6428	6690	9115	8495	8160	11286
Lignite	9765	10572	10743	9918	10331	10605	11187	12280	12414	12984
Oil	23901	23315	24865	28412	27142	29324	30939	30515	32083	32916
Natural gas	3110	3827	4197	4630	4921	6313	7384	9165	10635	12902
Total fossil	43267	44558	46608	49631	48822	52932	58625	60455	63292	70088
Renewable										
Hydropower	1991	1951	2285	2920	2630	3057	3481	3424	3520	3240
Geothermal	85	86	90	97	115	138	162	179	256	274
Solar	21	27	32	38	45	52	80	80	98	114
Wood	5361	5391	5421	5451	5482	5512	5512	5512	5512	5512
Waste & Dung	1847	1821	1788	1697	1627	1556	1533	1512	1492	1510
Total renewable	9305	9276	9616	10203	9899	10315	10768	10707	10878	10650
Total consumption	52572	53834	56224	59834	58721	63247	69393	71162	74170	80738
Total production	25123	25138	26408	26021	26059	26255	26926	27687	28784	27057

Source: WECTNC (1999); MENR (2001)

that was newly introduced into Turkish economy, has been growing rapidly. Turkey has large reserves of coal, particularly of lignite. The proven lignite reserves are 8.0 billion tons. The estimated total possible reserves are 30 billion tons. A majority of these lignite mostly situated in Afşin-Elbistan, Soma and Tunçbilek are characterized with high ash contents in the range of 14 to 42%, high moisture contents ranging from 15 to 50% and volatile matter contents of 16–38% . On the other hand, important developments have been recorded in primary energy and electricity consumption during the last forty years. In this period, primary energy consumption has increased by an average of 5.0 percent and electricity consumption by 10 percent, annually. Despite high growth rates, primary energy and electricity consumption are quite below the levels of OECD countries (WECTNC, 1999).

In 1999, primary energy production and consumption has reached 27 and 80.7 million tons of oil equivalent (mtoe) respectively (see Table 1). The most significant developments in production are observed in hydraulic energy and oil production. Oil production reached 4.5 million tons in 1991, the highest level in its history. Thus, the share of indigenous oil in total oil supply rose to 20 percent. However, this development could not be maintained in the following years, and production of oil has entered into a regression period.

As of the end of 1999, installed capacity and generation capacity of power plants reached 19,938 MW and 116,440 GWh, respectively. As of 1999, electricity demand is amounts to 88 billion kWh was met continuously with a high reserve margin. However, it is crucial to ensure the continuity of investments in order to meet electricity demand continuously and safely in the coming years is increasing rapidly.

The findings of the Ministry of Energy and Natural Resources suggest that the primary energy demand will be equivalent to 91,030 kilo tonnes of oil equivalent (Ktoe) in the year 2000, and 314,353 Ktoe in 2020 in Turkey. In line with this trend, in 2023 marking the centennial of the country, the primary energy consumption will reach 367 780 Ktoe and 407,106 Ktoe two years later in 2025. According to the Ministry's production forecasts, domestic production of primary energy will level 31,091 Ktoe in 2000 and 79,399 Ktoe by 2020. The projections foresee domestic generation to top 91,408 Ktoe in 2023 and 95,946 Ktoe in 2025. Table 2 gives the findings related to primary energy resources and their domestic production planning (TÜSİAD, 1998).

RENEWABLE ENERGY UTILIZATION

Renewable energy sources can meet many times the present world energy demand, so their potential is enormous. They can enhance diversity in energy supply markets, secure long-term sustainable energy supplies, and reduce local and global atmospheric emissions. They can also provide commercially attractive options to meet specific needs for energy services (particularly in developing countries and rural areas), create new employment opportunities, and offer possibilities for local manufacturing of equipment. On the other hand, there are many renewable technologies. Although often commercially available, most are still at an early stage of development and not technically mature. They demand continuing research, development, and demonstration efforts. In addition, few renewable energy technologies can compete with conventional

fuels on cost, except in some niche markets. But substantial cost reductions can be achieved for most renewables, closing gaps and making them more competitive. That will require further technology development and market deployment.

Hydropower

There are 436 sites available for hydroelectric plant construction, distributed on 26 main river zones. Table 3 shows water and energy potential of selected river basins in Turkey. The total gross potential and total energy production of this 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. The contribution of small hydroelectric plants to total electricity generation is estimated to be 5–10 percent (DSI, 1998; Kaygusuz, 1999b).

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; the land to be irrigated is more than half of the presently irrigated area in Turkey. GAP is an integrated development project; it is expected to affect the entire structure of the region in its economic, social and cultural dimensions through a process of transformations to be triggered by agricultural modernization. It is envisaged as the

Table 2. Primary energy production and consumption (in parenthesis) targets of Turkey between 2000–2025 (Ktoe)

Energy Sources	2000	2005	2010	2015	2020	2023	2025
Hard coal & lignite	17202	21259	28522	31820	39385	42732	45944
	(20256)	(30474)	(50311)	(83258)	(129106)	(198798)	(296997)
Oil & Natural gas	3408	2127	1735	1516	1604	1505	1455
	(59250)	(73256)	(92637)	(112993)	(136365)	(158467)	(179765)
Centralheating	253	495	884	1336	2018	2427	2748
	(253)	(495)	(884)	(1336)	(2018)	(2427)	(2748)
Hydropower	3763	5845	7520	8873	9454	10002	10445
	(3763)	(5845)	(7520)	(8873)	(9454)	(10002)	(10445)
Wood & Waste	6963	6760	6446	6029	5681	5498	5393
	(6963)	(6760)	(6446)	(6029)	(5681)	(5498)	(5393)
Geothermal	432	1380	3760	4860	4860	5400	5400
	(432)	(1380)	(3760)	(4860)	(4860)	(5400)	(5400)
Nuclear	0.0	0.0	3657	9143	18286	26988	29200
	(0.0)	(0.0)	(3657)	(9143)	(18286)	(26988)	(29200)
Solar	204	459	907	1508	2294	2845	3248
	(204)	(459)	(907)	(1508)	(2294)	(2845)	(3248)
Wind	55	250	620	980	1440	1786	2134
	(55)	(250)	(620)	(980)	(1440)	(1786)	(2134)

Source: WECTNC (1999)

means of bridging the gap between the south-eastern 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. Once completed, 27 billion kwh of electricity will be generated and irrigating 1.7 million hectares (Kaygusuz, 1999c).

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 Karakaya Dam, 2400 MW installed capacity from Ataturk Dam, and 1360 MW installed capacity from Keban Dam. There are also thermal power plants, fuelled by coal or lignite in the region. Tigris hydropower plant (HPP) and the 185.6 MW Batman HPP are under construction. When these power plants are completed, the installed capacity in the region will reach 5,960 MW and the total annual energy 21,900 GWh. The GAP region with this capacity will supply 25% of Turkey's electricity and 85% of its hydroelectric energy (DSI, 1998).

Biomass

Biomass energy includes fuelwood, agricultural residues, animal wastes, charcoal, and other fuels derived from biological sources is used by approximately half of the world's population as cooking and/or heating fuel and it currently accounts for about

Table 3. Water and energy potential of selected river basins in Turkey

Name of basin	Land area (km^2)	Average rainfall (mm/yr)	Number of Dam	Stored water (hm^3)	Installed capacity (MW)	Average generation (GWh)
Susurluk	22399	711.6	25	3509.3	537.0	1697
Gediz	18000	603.0	14	3369.4	250.0	425
B.Menderes	24976	664.3	19	2722.1	214.5	848
B.Akdeniz	20953	875.8	24	1836.6	674.7	2495
Antalya	19577	1000.4	15	2885.3	1251.6	4411
Sakarya	58160	524.7	45	6920.3	1062.5	2362
B.Karadeniz	29598	811.0	24	2518.8	592.7	2110
Yeşilırmnak	36114	496.5	45	6301.8	1657.6	6468
Kızılırmak	78180	446.1	82	21260.0	2007.0	6512
D.Akdeniz	22048	745.0	11	9121.5	1495.9	5176
Seyhan	20450	624	18	6124.5	1885.6	7117
Ceyhan	21982	731.6	25	7719.5	0408.7	4634
Fırat	127304	540.1	83	112791.5	9844.8	38939
D.Karadeniz	24077	1198.2	43	1522.5	3323.1	10927
Çoruh	19872	629.4	20	7544.4	3227.4	10614
Aras	27548	432.4	20	4084.8	585.2	2291
Dicle	57614	807.2	36	30295.0	5081.9	16876
Total Turkey	779452	642.6	702	240763.6	35309.2	124568

Source: DSI (1998)

14% of world energy consumption. Biomass is the main source of energy for many developing countries, providing more than 90% of energy supply in some developing country. Fuelwood and other biomass fuels are handled and combusted primarily by women, who are largely responsible for reproductive chores such as cooking and are often involved in any household industries. Women and children generally have the mam responsibility for collecting fuel. Previous studies show that there is an important potential for biomass in Turkey (Türker et al, 1999; Demirbaş, 1998; Türker and Kaygusuz 2001; Kaygusuz and Türker, 2001).

Among the renewable energy sources, biomass is important because its share of total energy consumption is still high. Since 1980, the contribution of the biomass resources in the total energy consumption dropped from 20 to 10% in 1998. Biomass in the forms of fuelwood and animal wastes is the main fuel for heaing and cooking in many urban areas. The total recoverable bioenergy potential is estimated to be about 16.92 mtoe The estimate is based on the recoverable energy potential from the main agricultural residues, livestock farming wastes, forestry and wood processing residues, and municipal wastes that given in the literature (Kaygusuz, 1997). Table 4 gives the calculated total recoverable bioenergy potential in Turkey.

On the other hand, fuelwood is important for rural area in Turkey as in other developing countries. About half of the world's population depends on fuelwood or other biomass for cooking and other domestic use. In 1998, an estimated 12.5 million steres of fuelwood were produced by the state, while from both public and private sectors recorded production was estimated at about 14.2 million steres from undeclared production. In other words, approximately half of the total demand for fuelwood is met by informal cutting in State forests and other sources of fuelwood in agricultural areas.

Scientific studies on energy forests began in 1980 with the Fourth Five-Year Development Plan in Turkey. As explained in the Seventh Five Year Development Plan, at present, heating and cooking requirements are greatly met by fuelwood in the rural area of Turkey. Therefore the new energy forests can be obtained to improve the country's forests, and future programs should be made by the government. However, using the forests as a fuelwood source instead of for industrial purposes is not economical. The wood contains much chemical raw materials, which can be used in

Table 4. Total recoverable bioenergy potential in Turkey (1998)

Type of biomass	Energy potential (ktoe)
Dry agricultural residue	4560
Moist agricultural residue	250
Animal waste	2350
Forestry & wood processing residues	4300
Municipality wastes & human extra	1300
Firewood	4160
Total bioenergy	16920

many industries such as pulp and paper, chemical, and furniture in the country (Kaygusuz and Türker, 1998; SPO, 2001).

Geothermal Energy

Turkey is one of the countries with significant potential in geothermal energy. Data accumulated since 1962 show that there may exist about 4500 MW of geothermal energy usable for electrical power generation in high enthalpy zones. Heating capacity in the country runs at 820 MWt equivalent to 52,000 households. These numbers can be heightened some sevenfold to 2,250 MWt equal to 350,000 households through a proven and exhaustible potential. Turkey must target 1.3 million households equivalent 7,700 MWt. Geothermal central heating, which is less costly than natural gas could be feasible for many regions in the country. In addition 31,000 MW of geothermal energy potential is estimated for direct use in thermal applications. The total geothermal energy potential of Turkey is about 2,268 MVV in 1998, but the share of geothermal energy production, both for electrical and thermal uses is only 1,200 MW. There are 26 geothermal district heating systems exist now in Turkey. Main city geothermal district heating systems are in Gönen, Simav and Kırşehir cities. To date, at least four other geothermal fields with electric power generating potential have been discovered and studied to varying degrees. These are: Seferihisar, Salvatlı, Simav and Dikili-Bergama. Holes drilled to evaluate these fields found temperatures up to 171˚C with variable degrees of permeability. The Turkish geothermists claim to have virtually overcome the consequences of scaling and corrosion in both high and low temperature wells, so it know that scientific research continues. Plans are to be generating 125 Mwe from Germencik, Kızıldere, Çanakkale and several of the other fields by the year 2000, 150 Mwe by 2005 and 258 Mwe by 2010 (Mertoğlu et al., 2000).

Solar Energy

Turkey lies in a sunny belt between 36˚ and 42˚N latitudes. The yearly average solar radiation is 3.6 kWh/m^2.day and the total yearly radiation period is approximately 2640 hour, (Table 5) which is sufficient to provide adequate energy for solar water and space heating. In spite of this high potential, solar energy technologies are not now widely used, except for flat-plate solar collectors. They are only used for domestic hot water production, mostly in the sunny coastal regions. Thermosyphon-type flat plate collectors have been used in Turkey since 1950, and at present about 30% of the installed systems are still of this type. However, the installations are mostly by trial and error. There are quite a large number of different manufacturers producing collectors with varying types and performances. In 1998, about 3.0 million m^2 solar collectors were produced and predicted that total solar energy production is about 0.080 Mtoe (million tons of oil equivalent). The global solar radiation incident on horizontal surface and bring sunshine hours are measured by all recording stations in Turkey (TÜSİAD, 1998; WECTNC, 1999).

Turkey, currently, does not have an organized photovoltaic (PV) program. Global energy strategies and policies are laid down in periodic five years development plans. Government has no intention in PV production. So far none of these studies yielded a positive result in order to justify a mass production facility in Turkey. Potential of

Turkey as a PV market is very large, since the country is very suitable in terms of insolation and large available land for solar farms. There are more than 30,000 small residential areas where solar powered electricity would likely be more economical than grid supply. Another potential for PV market is holiday villages at the long coastal areas. These facilities are frequently far from the main grid nodes and require additional power when solar insolation is high. Unfortunately energy demand in Turkey is so large that utilities are concentrating on large conventional power plants and peak load facilities. The newest five years development plan, being prepared, foresees a more ambitious program and estimates approximately 40 MWp installed power by the year 2010 (TÜSİAD, 1998).

Wind Energy

There are a number of regions in Turkey with relatively high wind speeds (see Table 5). These have been classified into six wind regions, with a low of about 3.5 m/s and a high of 5 m/s at 10 m altitude, corresponding to a theoretical power production between 1000 and 3000 kWh/(m^2.yr) . The most attractive sites are the Marmara Sea region, Mediterranean Coast, Agean Sea Coast, and the Anatolia inland (TÜSİAD, 1998; WECTNC, 1999). Turkey's first wind farm was commissioned in 1998, and has a capacity of 1.5 MW. Capacity is likely to grow rapidly, as plans have been submitted for just under a further 600 MW of independent facilities. The majority of proposed projects are located in the Çeşme, İzmir and Çanakkale regions. Electrical power resources survey and development administration (EIE) carries out wind measurements at various locations to evaluate wind energy potential over the country, and have started to compile a wing energy atlas (in cooperation with other organisations). Approval of independent wind energy projects requires at least a six months history of wind measurements.

ENVIRONMENTAL IMPACTS OF ENERGY UTILIZATION

Energy and environment were much discussed at the June 1992 UN Conference on

Table 5. Solar and wind energy potential by regions of Turkey

	Annual average wind density (W/m^2)	Annual average wind speed (m/s)	Annual average solar radiation (kWh/m^2-yr)	Sunshine duration (hour/yr)
Marmara	51.91	3.29	1168	2409
Southeast Anatolia	29.33	2.69	1460	2993
Aegean	23.47	2.65	1304	2738
Mediterranean	21.36	2.45	1390	2956
Black Sea	21.31	2.38	1120	1971
Central Anatolia	20.14	2.46	1314	2628
East Anatolia	13.19	2.12	1365	2664
Turkey Average	25.81	2.57	1303	2623

Source: TÜSİAD (1998)

Environment and development in Rio de Janeiro. Agenda 21, produced at the Rio Summit, reached the conclusion that the present energy course is unsustainable. Chapter nine of Agenda 21, "Protection of the Atmosphere" begins:

"Energy is essential to economic and social development and improved quality of life. Much of the world's energy, however, is currently produced and consumed in ways that could not be sustained if technology were to remain constant and if overall quantities were to increase substantially. The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on efficiency in energy production, transmission, distribution and consumption, and on growing reliance on environmentally sound energy systems, particularly new and renewable sources of energy."

Air pollution is becoming a great environmental concern in Turkey. Air pollution from energy utilization in the country is due to the combustion of coal, lignite, petroleum, asphaltite, natural gas, wood and agricultural and animal wastes. In Turkey the amount of CO_2 emissions was about 79 million tons in 1998. The amount of carbon emission per person was about 1102 kg, and per square kilometer was 102 tons. The total amount of carbon emissions will increase to 83–93 million tons in the year 2000 and to 128–166 million tons in 2010, according to the probable portion approach method (TÜSİAD; 1994). On the other hand, the amount of carbon emissions is less by 14–16% with the economic sensitivity approach method, which gives these amounts as 77–86 million tons in 2000 and 110–140 million tons in 2010 (Table 6).

Owing mainly to the rapid growth of primary energy consumption and the increasing use of domestic lignite, SO_2 emissions in particular have increased rapidly in recent years in Turkey. According to the estimates given by the Ministry of Energy and Natural Resources (MENR), total SO_2 emissions in Turkey were about 2100 thousand tons in 1998. In the present study, the total SO_2 emissions in Turkey were calculated as 2235 thousand tonnes in 1998. The major source of SO_2 emissions is the power sector, contributing more than 50% of the total emissions. As given in the literature (Tasdemiroğlu, 1994; TÜSİAD, 1994), SO2 concentrations in the flue gas of some lignite-fired power stations are extremely high and differ notably between power

Table 6. Predicted emissions of carbon from combustion sources in Turkey

		2000			2010		
	1998	Low	Normal	High	Low	Normal	High
Emission (million tonnes)							
Possible portion	78.6	83.4	88.2	92.7	128.2	145.9	165.7
Economical portion	72.7	77.5	81.6	85.8	109.5	123.1	139.4
Emission (tonne/km^2)							
Possible portion	102.2	107	113	119	164	187	212
Economic portion	94.2	99	105	110	140	158	179
Emission (kg/person)							
Possible portion	1102	1202	1271	1336	1543	1755	1994
Economic portion	1017	1117	1176	1236	1318	1482	1677

plants, owing to the variation of the sulphur content of the fuels. Table 7 gives the amount of SO_2 emissions from combustion sources in 1998, 2000, and 2010 for Turkey. As shown in Table 7, amount of SO_2 emissions per person and per square kilometre were about 32.4 and 2.2 thousand tonnes in 1998, respectively. These values will be change between 28.4–38.1 and 3.0–4.1 thousand tonnes in 2010.

Although the NO_2 emissions are lower than SO_2 emissions in Turkey, they have likewise increased rapidly, following the growth of energy requirements. Contrary to the development of SO_2 emissions, a similar upward trend of NO_2 emissions has been observed in many European Community countries as well, resulting mainly from the increased traffic density. Also in Turkey, nearly 50% of the total NO_2 emissions are from the transportation sector, while less than 20% are caused by power generation. Per capita NO_2 emissions are still much lower in Turkey than in the European Community countries, i.e., less than one-third of these countries average. Table 8 gives the amount of NO_2 emissions in 1998, 2000 and 2010 for Turkey. As shown in Table 8, amount of NO_2 emissions per person and per square kilometre were about

Table 7. Predicted emissions of SO_2 from combustion sources in Turkey

		2000			2010		
	1998	Low	Normal	High	Low	Normal	High
Emission (thousand tonnes)							
Possible portion	2235	2337	2492	2641	2356	2737	3163
Economical portion	2064	2165	2303	2439	1977	2265	2609
Emission (tonne/km^2)							
Possible portion	2.2	3.0	3.2	3.4	3.0	3.5	4.1
Economic portion	1.9	2.8	3.0	3.1	2.5	2.9	3.3
Emission (kg/person)							
Possible portion	32.4	33.7	35.9	38.1	28.4	32.9	38.1
Economic portion	30.2	31.2	33.2	35.1	23.8	27.3	31.4

Table 8. Predicted emissions of NO_2 from combustion sources in Turkey

		2000			2010		
	1998	Low	Normal	High	Low	Normal	High
Emission (thousand tonnes)							
Possible portion	1219	1319	1389	1461	2027	2280	2565
Economical portion	1117	1217	1278	1343	1746	1950	2187
Emission (tonne/km^2)							
Possible portion	1.3	1.7	1.8	1.9	2.6	2.9	3.3
Economic portion	1.2	1.6	1.6	1.7	2.2	2.5	2.8
Emission (kg/person)							
Possible portion	17.4	19.0	20.0	21.1	24.4	27.4	30.9
Economic portion	15.3	17.5	18.4	19.4	21.0	23.5	26.3

17.4 and 1.3 thousand tonnes in 1998, respectively. These values will be change between 24.4–30.9 and 2.2–2.8 thousand tonnes in 2010. As a result, we say that, environmental and health related risk exposures are valid for all energy types. Nevertheless such environmental effects can be mitigated through the use of advanced science and technological tools. Human beings do factor employ controllable all forms of energy technologies necessitate measures to protect the environment.

CONCLUSIONS

To achieve even the modest environmental goals of the Kyoto Protocol accords requires the sustained and orderly commercial development of viable renewable energy options. It is not enough for government to support the development of renewable energy technologies, it must also support their commercial application in the country. If support of renewable energy research and development is an appropriate use of public funds, so too is purchasing the fruits of these research programs. Like health care, education, the construction and maintenance of roads and national defence, renewable energy is public good.

Due to the fact that Turkey is an energy importing country and coal fired power plants produce a significant amount of pollutants (CO_2, SO_2, NO_2 and particulate matter), the country must use its own clean and domestic energy sources, especially hydropower, biomass, geothermal, solar and wind power sources. In terms of environmental protection, hydropower, solar and wind energy are the most effective options available today for Turkey. In case of hydropower, it is estimated that 2,500 billion kWh of power generated by hydroelectric plants in 1997 prevented the release of more than two billion metric tons of CO_2 to the atmosphere, which would have otherwise arisen from generation of this power in coal-fired power plants. This volume of CO_2 corresponds to about one-tenth of the worldwide emissions caused by power generation (Kaygusuz et al., 1996).

Renewable energy resources and their utilisation in Turkey are intimately related to sustainable development. For the governments or societies to attain sustainable development, much effort should be devoted to utilising sustainable energy resources in terms of renewables. In addition, environmental concerns should be addressed. The following concluding remarks can be drawn from this study:

- Many homes lose more than half their heat through exterior walls, floors and roofs. Therefore it needs well insulation to reduce heat loss. After weatherization, adding insulation is one of the cheapest ways to reduce heating bills.
- Most of the buildings in Turkey are not designed to accommodate renewable energy systems especially in towns. The space availability for installation of such systems is limited and the benefit of the renewable energy technology is still not fully recognized by the public.
- The household sector should use high efficiency coal and wood stoves which feature air control inlets and separate primary and secondary combustion chambers or use catalytic combustors. These stoves are about 60 to 75% efficient, compared with conventional stoves which are 20 to 30% efficient.

- There are a number of environmental problems in the country that we face today. These problems span a continuously growing range of pollutants, hazards and ecosystem degradation over the country. So, all government agencies and other nongovernmental agencies in the country must work together to utilise their renewable energy and choose the appropriate application for Turkey.
- Development of advanced renewable energy technologies is required which will serve as cost-effective and environmentally friendly alternatives to conventional energy generation systems. Therefore, the governmental energy institutions and special sector agencies should be recognise this opportunity.
- The technology of hydropower has proven itself over a long period of time and is very reliable. The actual service of hydroelectric power plant is extremely long in comparison to other types of power plants. This makes water power very attractive from an economic point of view.
- Water is continually regenerated and available at no cost. It use generates no harmful emissions to burden the environment. Water power also yields great ecological and economic benefits when coupled with flood protection, river engineering, raising of the groundwater level, irrigation, and the supply of drinking water.
- Solar, geothermal and wind energy present a considerable opportunity for our country to obtain a significant part of our future energy needs from these sustainable, domestic and clean energy sources.
- Recognition of ecological benefits and impact should be included in the price of any energy source and would greatly advantage geothermal projects. So, to achieve growth, there is need to inform and stimulate political decision-makers and industrialists and to make the general public, potential customer, aware of the benefits of geothermal use in Turkey.
- Studies for exploration of new coal lands should continue to sustainable development in energy sector. Special importance should be given for the use of most proper burning technologies for Turkish lignites to obtain clean environment for future.
- Due importance should be given to river type small hydroelectric power plants. Considering the energy need of the country, domestic manufacturing and installation of machinery and equipment of these small hydroelectric plants should be encouraged.
- Biomass energy (especially woodfuel) presents a considerably opportunity for Turkey to obtain a significant part of our future energy needs from this sustainable energy source. At present, modern technologies are increasingly being applied to woodfuel development. Many industrialised countries are deliberately increasing wood energy use, for environmental and socio-economic reasons.

BIBLIOGRAPHY

Demirbaş, A. (1998). "Yields of Oil Products from Thermochemical Biomass Conversion Processes", Energy Conversion and Management, Vol. 39, pp. 685–690.

Kaygusuz, K., Kargı, H., and Kaygusuz, A. (1996). "Role of the Clean Energy Potential for Energy Savings and Air Pollution Control in Turkey", Energy Sources, Vol.18, pp. 885–901.

Kaygusuz, K. (1997). "Rural Energy Resources: Applications and Consumption in Turkey", Energy Sources, Vol. 19, pp. 549–558.

Kaygusuz, K., and M.F, Türker. (1998). "The Use of Wood as an Energy Source in Turkey", Energy Sources, Vol. 20, pp. 605–614.

Kaygusuz, K. (1999a). "Energy Situation, Future Developments, Energy Saving, and Energy Efficiency in Turkey", Energy Sources, Vol. 21, pp. 405–416.

Kaygusuz, K. (1999b)."Hydropower Potential in Turkey" Energy Sources, Vol.21,pp. 581–588.

Kaygusuz, K. (1999c). Energy and Water Potential of the Southeastern Anatolia Project (GAP) Energy Sources, Vol. 21, pp. 913–922.

Kaygusuz, K., and Türker, M.F. (2001). "Biomass Energy Potential in Turkey", Renewable Energy (accepted for publication).

Ministry of Energy and Natural Resources (MENR). (2001). Energy Statistics of Turkey. http://www.menr.gov.tr/energy.html

Mertoğlu, O., T. Özbek, Ş. Şimşek., H. Kara and N. Kanyılmaz. (2000). "Present Situation of Geothermal Energy in the World and in Turkey", Turkish J. of Geothermal, Vol. 2, pp 13–17.

State Planning Organization. (2001). Eighth five-year development plan. DPT, Ankara, Turkey: Forestry Special Impression Commission Report (in Turkish).

State Water Works (DSI). Statistical bulletin with map in 1997, Ankara, Turkey, 1998.

Taşdemiroğlu, E. (1994). "Environmental Damage due to Thermal Power Generation in Türkiye", Energy, Vol. 19, pp. 1235–1244.

Turkish Industrialists' and Businessmen's Association. (1994). Future view of Turkish energy sector: Supply, demand and policies (in Turkish by V. Şahin). TÜSİAD, Istanbul, Turkey.

Turkish Industrialists' and Businessmen's Association. (1998). Turkey's energy strategy on the brink of the 21st century: an overview (Turkish by M, Ultanır). TÜSİAD, Istanbul, Turkey.

Türker, M.F., H, Ayaz, and K, Kaygusuz. (1999). "Forest biomass as a source of renewable energy in Turkey", Energy Sources, Vol. 21, pp. 705–714.

Türker, M.F., and Kaygusuz, K. (2001). Investigation of the Variables Effects on Fuelwood Consumption as an Energy Source in Forest Villages of Turkey", Energy Conversion and Management, Vol. 42, pp. 1215–1227.

World Energy Council Turkish National Committee (WECTNC). Energy report of Turkey in 1998, Ankara, Turkey, 1999.