Carbon Dioxide Emission Trends and Environmental Problems in Turkey

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ABSTRACT

Turkey's carbon emissions have risen in line with the country's energy consumption. However, energy-related CO_2 emissions per capita and per gross domestic product are both increasing. Energy-related CO_2 emissions from coal and coal products decreased slightly between 1990 and 2000 while that of oil and gas increased. As CO_2 emissions increased from 160 Mt in 1995 to nearly 240 Mt in 2000, they are expected to rise to 400 Mt by 2010 and up to 700 Mt by 2020. In Turkey total CO_2 emissions from fossil fuels, about 50.07 Mt in 2001. However, fuel share of carbon emissions in 2001: oil 44.2%, coal 38.8%, and NG 16.9%.

INTRODUCTION

Emissions of carbon dioxide (CO_2) caused by human activity are generally considered the most important (IPCC, 1992; Balat et al., 2003). The continued use of fossil fuels to meet the majority of the world's energy demand is threatened by increasing concentrations of CO_2 in the atmosphere and concerns over global warming (Yu et al., 2003).

Global warming has been increasingly associated with the contribution of CO2. Currently, it is estimated that CO_2 contributes about 50% to the anthropogenic greenhouse effect (Demirbas, 2003a).

The risk of climate change due to emissions of CO_2 from fossil fuels is considered to be the main environmental threat from the existing energy system. Other environmental problems are acidification, and dispersion of metals originating from fossil fuels (Johansson and Lundqvist, 1999; Demirbas, 2003a; Balat et al., 2003).

CO_2 and CO are main greenhouse gases (GHGs) associated with global warning. At the present time, coal is responsible for 30–40% of world CO_2 emissions from fossil fuels (Demirbas, 2003a; Balat et al., 2003; Balat and Ayar, 2004). Except for the fact that coals, gas and oil are running out, the combustion of fossil fuels is the most important cause of the increased CO_2-standard in the atmosphere (80% can be contributed to this). This increase of the CO_2-standard is responsible, worldwide, for more than half of the so-called greenhouse-effect (heating-up of the earth) (Demirbas, 2000a).

Global CO_2 emissions from fossil fuel combustion increased from 20.7 billion tons in 1990 to 23.7 billion tons in 2001, a 14.6% rise, albeit with significant variations among regions. OECD CO_2 emissions from fuel combustion increased 13% between 1990 and 2001 (IEA, 2003). Figure 1 shows total CO_2 emissions by region during 1981–2001.

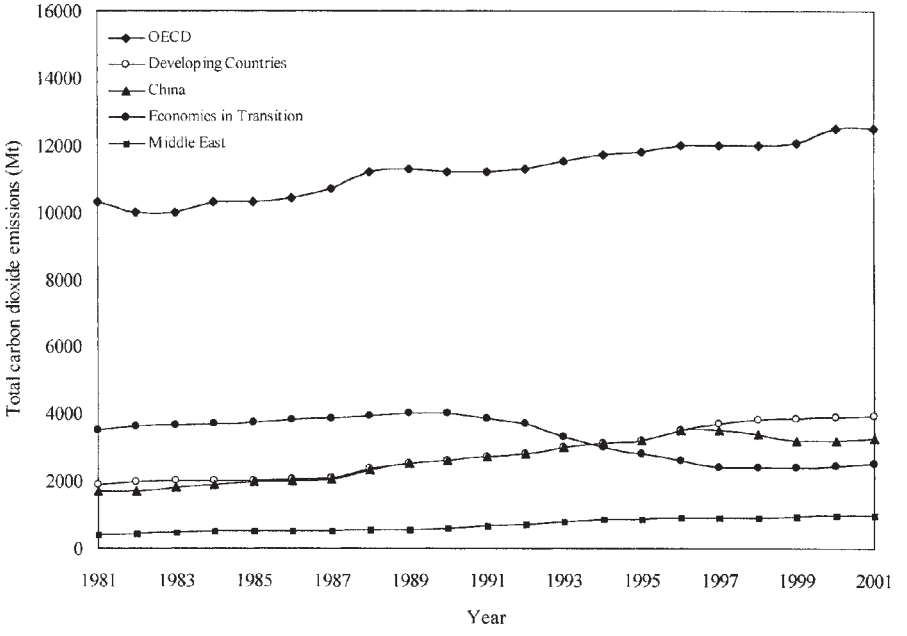

Figure 1. Total CO_2 emissions by region during 1981–2001
(Source: IEA gas statistics, 2003)

The sorbent energy transfer system (SETS) has the potential for providing a significant reduction in CO_2 emissions from gaseous fossil fuel-fired electric power plants with minimal loss in power generating efficiency. Energy transfer is accomplished in two steps so that CO_2 does not come in contact with combustion air, thereby avoiding a costly and energy intensive CO_2 separation step. In the first step, gaseous fuel is oxidized by reduction of an appropriate metal oxide sorbent. The gas product contains only CO_2 and H_2O so that pure, sequestration-ready CO_2 is obtained after removing H_2O by condensation (Yu et al., 2003; Balat et al., 2003).

Hydroelectric is a proven technology for electricity production capable of generating large amounts of power. It is entirely renewable and causes no CO_2 emissions (Topçu and Ulengin, 2004).

The use of biomass fuels provides substantial benefits as far as the environment is concerned. Biomass absorbs CO_2 during growth, and emits it during combustion. Therefore, biomass helps the atmospheric CO_2 recycling and does not contribute to the

greenhouse effect. Biomass consumes the same amount of CO_2 from the atmosphere during growth as is released during combustion (i.e. biomass is considered CO_2 –

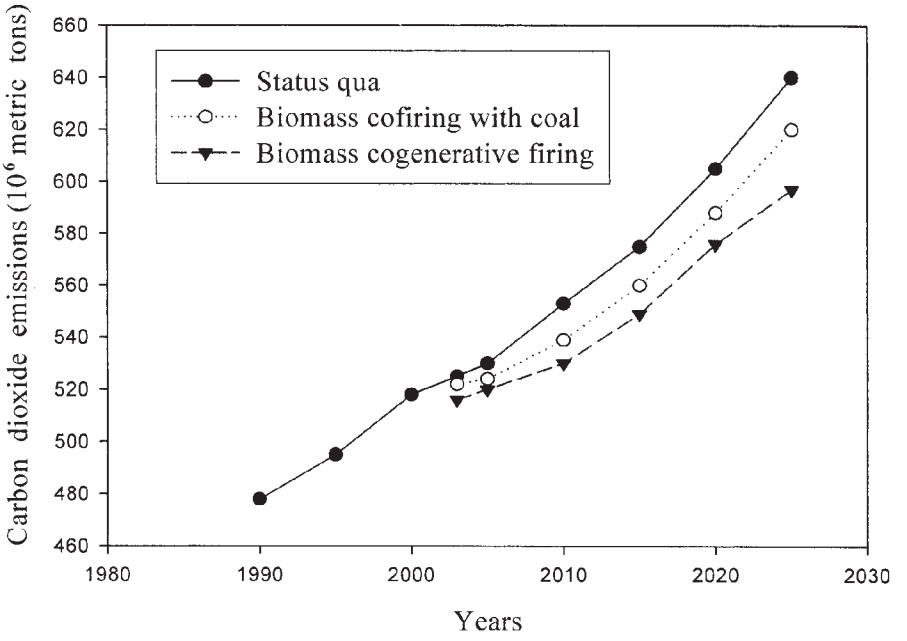

Figure 2. Plots for coal with biomass in pulverized coal boilers to reduce fossil based carbon emissions: Status qua and alternative firing scenarios.

neutral fuel). In addition, overall CO_2 emissions can be reduced because biomass is a CO_2 neutral fuel. Therefore, blending coal with biomass fuels can reduce fossil-based CO_2 emissions (Sami et al., 2001; Demirbas, 2003b). Global warming is mainly caused by CO_2 emissions and is responsible for at least half of the warming. Figure 2 shows the status qua and alternative co-firing and cogeneration scenarios.

Wood fuel has several environmental advantages compared with fossil fuels. Wood can be continually replenished, which leads to a sustainable and dependable supply. There is little net production (~5%) of CO_2, the major greenhouse gas, from wood combustion because the CO_2 generated during combustion of the wood equals the CO_2 consumed during the lifecycle of the tree.

CO_2 EMISSIONS IN TURKEY

Turkey's carbon emissions have risen in line with the country's energy consumption (Senguler, 2001). Table 1 shows Turkey's CO_2 emission/capita compared to other countries. Although the demand of the country increases rapidly, Turkey's contribution to global GHG emissions is considerably below the average of Annex I countries. Turkey has the lowest energy related CO_2 emissions per capita among IEA

Table 2. Electric power capacity development in Turkey

Fuel	2010		2020	
	Installed capacity (MW)	Generation (GWh)	Installed capacity (MW)	Generation (GWh)
Coal	16,106	104,035	26,906	174,235
Natural gas	18,856	125,548	34,256	225,648
Fuel oil and Diesel	3,125	17,993	8,025	49,842
Nuclear	2,000	14,000	10,000	70,000
Hydro and Renewables	24,982	85,719	30,031	104,043
Total	65,069	347,294	109,218	623,768

Source: TMMOB, 2003

Table 3. Lignite reserves and production in some of TKI mines, 2001

Mine	Reserves (1000 tons)	Production (ton/year)
Alpagut-Dodurga	16,797	300,000
Askale	162	20,000
Oltu	693	50,000
Silopi*	49,313	700,000
Saray*	129,123	700,000
Göynük*	39,000	700,000

*Characteristics of reserves suitable for power plants contruction

Source: Ersoy and Anaç, 2002

countries (Demirbas, 2003a). Energy-related CO_2 emissions from coal and coal products decreased slightly between 1990 and 2000 while that of oil and natural gas increased (Senguler, 2001).

Coal contains proportionally more carbon than NG. Methane is itself a greenhouse gas, which molecule for molecule can trap more heat than CO_2 this way counterbalance the CO_2 benefits of burning NG instead of coal (Demirbas, 2000a; Surmen and Demirbas, 2003; Balat and Ayar, 2004).

Several transmission pipelines are being considered to bring natural gas from Iran and the Caspian area, as well as to increase imports from Russia. These imports are welcome, as they will further diversify Turkish energy supply and will contribute to the mitigation of urban pollution and CO_2 emissions to the extent that natural gas replaces more carbon intensive fuels.

If Turkey's energy consumption and CO_2 emissions are projected basing on the energy consumption patterns in 1992 (Table 2) and compared to the projections based on the consumption patterns in 1996 (Table 3), which is the actual case, it can be realized that if Turkey had not considered policy change regarding global warning since 1992, the CO_2 emissions would be 20% higher in 2010 (Demirbas, 2003a).

In Turkey, CO_2 is a key pollutant associated with the energy and transport sectors. Hence CO_2 emissions in Turkey are still the lowest among OECD countries in terms

of per capita emissions, they have been increasing rapidly as there is a continuing increase in demand for energy. CO_2 emissions reach approximately 191 million tons (Mt) in 1997, with a 34 percent increase since 1990. Coal use is responsible for half of Turkey's CO_2 emissions, whilst oil represent 46 percent and natural gas consumption less than 4 percent (ESMAP, 2000; Sahin, 2003).

As CO_2 emissions increased from 160 Mt in 1995 to nearly 238 Mt in 2000. CO_2 emissions are expected to rise to 400 Mt by 2010 and up to 700 Mt by 2020 (ESMAP, 2000; Sahin, 2003). Figure 3 shows CO_2 emissions by sector in Turkey.

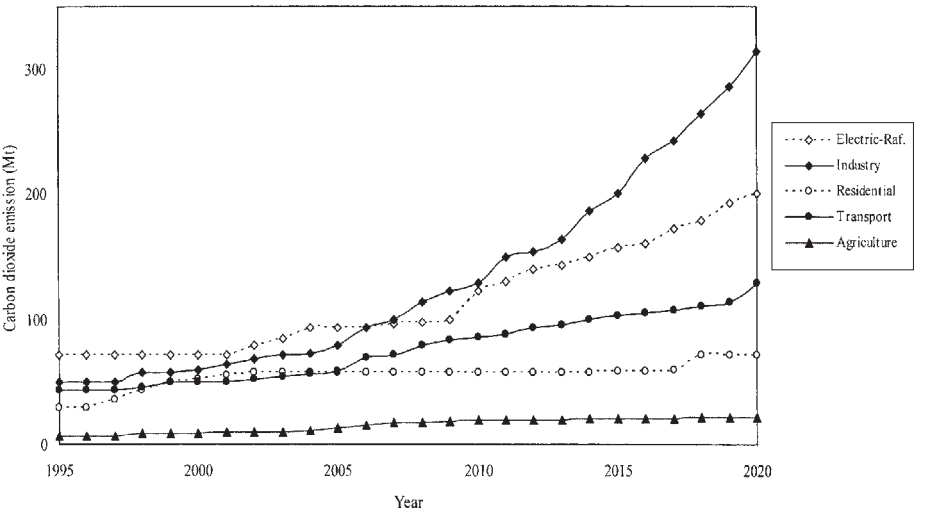

Figure 3. CO_2 emissions by sector in Turkey during 1995–2020

In Turkey total CO_2 emissions from fossil fuels, about 50.07 Mt in 2001 (FEI, 2003). However, fuel share of carbon emissions in 2001: oil 44.2%, coal 38.8%, and NG 16.9% (FEI, 2003; EIA, 2003). An historical summary of CO_2 emissions from fossil fuel use in Turkey is shown in Table 4. Total CO_2 emissions from fossil fuels are expected 104 Mt in 2025 (Table 5) (EIA, 2003).

Geothermal energy is considered to be a benign energy source as regards environmental impact. One of its impacts is the release of the greenhouse gas, CO_2 to the atmosphere (Armannson, 2003). The main uses of geothermal energy in Turkey are: space heating and domestic water supply, greenhouse heating, balneology, CO_2 and dry ice production process, heat pumps and electricity generation (Gokcen et al., 2004).

By heating 52,000 residences equivalence by geothermal energy in Turkey, 516,000 tons of CO_2 emission has not been discharged to the atmosphere. This is equivalent to avoiding 310,000 cars from the traffic (as of peak emission amount in January) and 660,000 tons/year oil saving (Mertoglu et al., 2001).

Table 1. Gross electrical energy generation by energy sources in 2002–2003 fourth quarter (GWh)

Energy sources	2002 IV. Quarter (Oct.–Nov.–Dec.)		2003 IV. Quarter (Oct.–Nov.–Dec.		2003 Annual	
	Quantity	%	Quantity	%	Quantity	%
Thermal						
Lignite	6,705.6	20.08	6,501.6	17.95	23,630.0	16.85
Hard coal	1,073.0	3.21	3,293.5	9.09	8,718.9	6.22
Fuel-Oil	2,402.6	7.19	1,977.0	5.46	8,661.5	6.17
Diesel oil	55.6	0.17	0.0	0.00	0.2	0.00
Natural gas	13,873.6	41.54	16,252.4	44.88	62,300.3	44.41
Geothermal	22.7	0.07	21.8	0.06	88.6	0.06
LPG	3.3	0.01	96.3	0.27	369.4	0.26
Naphtha	255.9	0.77	346.0	0.96	1,059.5	0.76
Other	46.8	0.14	14.6	0.04	70.1	0.05
Thermal total	24,439.1	73.18	28,503.2	78.71	104,898.5	74.78
Wind	12.2	0.04	15.7	0.04	61.4	0.04
Hydro	8,945.0	26.78	7,693.9	21.25	35,323.6	25.18
General total	33,396.3	100.00	36,212.0	100.00	140,283.5	100.00

Source: SIS, 2004

Industrial usage of geothermal energy is not common in Turkey. The most well known application is liquid CO_2 and dry-ice production process operating adjacent to the Denizli-Kizildere geothermal power plant since 1986. The process installed with a capacity of 40,000 tons/year then the capacity was increased to 120,000 tons/year in 1999 (Gokcen et al, 2003).

In case Turkey reaches to the foreseen wind power capacities (2100 MW by the year of 2010), Turkey can mitigate the pollution coming from the thermal power plants. As a result, nearly (EIE, 2002):

_ 5.04 Mt CO_2
_ 58,683 tons SO_2
_ 17,604 tons NO_x will be avoided in Turkey.

ENVIRONMENTAL PROBLEMS AND POLICIES

Turkey's high rate of economic growth experienced during much of the 1990s, besides resulting in booming industrial production, also led to higher levels of energy consumption, imports, air and water pollution, and greater risks to the country's environment. Air pollution is a major problem in Turkey, with key pollutants including SO_2, suspended particulates, NO_x, and CO_2 (EIA, 2002).

The Regulation on Environmental Impact Assessment (EIA) was put into force on 7th of February 1993 and prescribes administrative and technical principles. Under the Regulation on Hazardous Waste Control (1995), ash and slag, disposed from coal-

fired power stations and gypsum from flue gas desulfurisation plants (FGD plants) are solid wastes and the Ministry of Environment defines the rules. The Regulation on Noise Control was brought into force in 1986. The Regulation and Control of Harmful Chemical Substances and Products was issued in 1993 to implement programs, policies and principles of legal, technical and administrative control of dangerous chemicals (Demirbas, 2001; Demirbas; 2003a; Balat and Ayar, 2004).

A National Climate Co-ordination Group (NCCG) has been established in Turkey. That carries out the national studies in line with those conducted by all countries of the Framework Convention on Climate Change. Those studies are based on the decisions of the Government. The State Planning Organization (SPO) is co-ordination a project, named "Turkish National Environmental Strategy and Action Plan", which is supported by the World Bank. This project is considered important in starting the activities related to Agenda 21, adopted in Rio Conference as soon as possible. The Government plans to develop that Strategy and an Action Plan to establish basic environmental standards, to determine an action plan that can be integrated with the overall development Program, and to identify environmental investment priorities (Demirbas, 2001).

Turkey made great progress over the last 15 years in creating mechanisms to address its environmental problems: the 1982 Constitution recognizes the right of citizens to live in a healthy and balanced environment; an Environment Act was passed in 1983; the Ministry of Environment was establish in 1991; public awareness and demand for a clean environment are growing; and active non-governmental environmental organizations are emerging (Demirbas, 2003a; Balat and Ayar, 2004).

This inadequacy is recognized and development of a national environmental strategy is called for in Turkey's Seventh Five-Year Development Plan for 1996–2000 which is the main instrument for coordinating government policies, including those for environmental management.

Thus, the National Environmental Action Plan (NEAP) which has been prepared over a two-year period responds to the need for a strategy and can supplement the existing Development Plan with concrete of the topics in its context. The options related to energy and environmental policies are:

- Measures to encourage wider use of natural gas.
- Support the utilization of clean and renewable energy sources as well as passive solar energy applications.
- Decentralization in energy generation.
- Optimizing sustainability of energy supply and environmental costs.
- Setting integrated energy consumption targets for Organized Industrial Zones.

Economic instruments, including carbon taxes and subsides, and allocation of research and development resources, are driven by energy policy goals and can change the competitiveness of renewable, especially biomass energy for Turkey. Future supply of biomass energy depends on energy prices and technical progress, both of which are driven by energy policy priorities (Demirbas, 2000b).

Adding proposals existing energy policies are:

Table 4. Coal-fired power plants in Turkey

Generating facility	Owner	Location (province)	Capacity (MW)
Afsin-Elbistan A	TEAS	K. Maras	1,360
Soma	TEAS	Manisa	1,034
Yatagan	TEAS	Mugla	630
Kemerkoy	TEAS	Mugla	630
Seyitomer	TEAS	Kutahya	600
Cayirhan	Park Termik Elektrik Sanayi ve Ticaret	Ankara	450
Tuncbilek	TEAS	Kutahya	429
Yenikoy	TEAS	Mugla	420
Kangal	TEAS	Sivas	300
Catalagzi	TEAS	Zonguldak	300
Orhaneli	TEAS	Bursa	210

Source: FEI, 2003

Table 5. Lignite fields suitable for electricity generation in Turkey

Project name	Reserve (1000 tons)	Lignite consumption capacity (tons/year)	Installed capacity (MW)
TKI			
Adana-Tufanbeyli	214,000	7,200	600
Bingol-Karliova	88,000	1,115	100
Bolu-Goynuk	39,000	1,200	150
Cankiri-Orta	51,000	1,500	100
Tekirdag-Saray	129,000	2,500	300
EUAS			
Cayirhan 5-6	75,000	2,500	320
Elbistan	2,818,000	86,400	6,300
Private Sector			
Konya-Ilgin	152,000	3,100	500
Adiyaman-Golbasi	49,000	1,400	125
Total	3,615,000	106,915	8,495

Source: Ersoy, 2003

- Taking into consideration supply costs of energy imports and expansion of natural gas use in power generation and in residential sector
- Utilizing nuclear power as non CO_2 emitter energy source
- Employing solar energy in heating
- Promoting bio-climatic design of buildings
- Promoting energy efficient technologies and reducing losses in energy conversion, transmission and distribution
- Installing emission control and reduction systems in all thermal power plants

- Promoting mass transportation systems, completing standards related to energy production and consumption systems
- Increasing use of alternative energy sources in transportation sector such as natural gas-operated municipal buses and electricity based railway systems
- Promoting clean car technologies including green-trucks, encouraging use of LPG in cars and supporting co-generation applications
- Considering environmental factors in the fuel cycles from energy production to consumption.

Recently, environmental problems resulting from energy production, conversion and utilization have caused increased public awareness in all sectors of the public, industry and government in both developed and developing countries. Major potential solutions to environmental problems are (Dincer, 2001):

- Cleaner technologies,
- Renewable energy technologies,
- Energy conversion technologies.

In which each one has a crucial impact on the environment in terms of the following:

- Reduction in ambient pollution,
- Decrease in emissions,
- Decrease in wastes sent to final disposal,
- Reduction in energy consumption,
- Reduction in the use of raw materials.

CONCLUSION

CO_2 is the main GHGs associated with global warming. Carbon assessments can play an important role in a strategy to control CO_2 emissions while raising revenue. In order to limit international emissions of GHGs, the authorities introduced carbon assessments.

Turkey's carbon emissions have risen in line with the country's energy consumption. In Turkey, CO_2 is a key pollutant associated with the energy and transport sectors. Turkey has the lowest energy related CO_2 emissions per capita among IEA countries.

In Turkey, CO_2 emissions increased from 160 Mt in 1995 to nearly 238 Mt in 2000 (Table 3). CO2 emissions are expected to rise to 400 Mt by 2010 and up to 700 Mt by 2020 (ESMAP, 2000; Sahin, 2003).

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