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Issues in Urban Air Pollution: Ankara Diagnostic Report

Iona Sebastian

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This is one of a series of three case studies looking into issues related to air pollution in urban areas. The remaining two refer to Mexico City and Beijing. The case studies are based on fact-finding missions to the countries, carried out by the World Bank and the World Health Organization (WHO) with financing provided under the Norwegian Trust Fund for health and the environment, and various other consultants trust funds. The paper reports on findings that are particularly significant in the context of the overall work program of the Environmental Policy and Research Division.

Ms. Iona Sebastian, Economist in the Environment Department of the World Bank, and the author of this paper, was the Mission Leader. Mr. Sam Ozolins, Air Pollution Specialist, represented the WHO and contributed to the mission report, along with Ms. Neeloo Bhatti, Environmental Specialist and Dr. Gunnar Nordberg, Environmental Health Specialist, Consultants. The author is indebted to Mr. Robert V. Pulley, EM1IN, for his thorough review of the paper and insightful comments.

ABSTRACT

This case study examines the direct causes of air pollution in Ankara. It identifies the health effects most likely to be associated with the dominant air pollutants, and reviews opportunities and constraints for reducing air pollution.

The first chapter of the paper describes the economic conditions prevalent in the country since 1980. The discussion goes in some detail into the energy sector, mainly trends, sources of energy and pricing policies, in view of their impact on the type and quantity of emissions of air pollutants.

The second chapter discusses the geographical and meteorological conditions specific to the city of Ankara. These account for the fact that air pollutants stagnate over approximately the same area where generated and threaten the health of the inhabitants. After discussing the levels of known pollutants, the institutional and legislative setting to deal with pollution, and its possible health consequences, in the next chapter, the paper summarizes the main issues involved in finding a cost-effective solution to the air pollution problem in Ankara.

The last chapter of the paper reviews the information needed to carry out the analysis of the economic consequences of air pollution control strategies, and to identify the macroeconomic measures to which a pollution control policy would be most responsive. The paper closes with a step by step description of the analysis that should be carried out to choose a cost-effective pollution control strategy that meets both health and economic development objectives.

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I. INTRODUCTION

Urban air pollution is a major environmental problem in many countries. It has serious immediate and long-term implications for the health and quality of life of the urban and surrounding rural populations. To the extent that it diverts resources into health care and reduces the productivity of the labor force, it also retards economic growth. Particularly for developing countries, slower growth, in turn, limits the resources available for the modernization of industry and production processes, which further deepens the pollution problem.

While the nature of this economic/environmental relationship is becoming better understood, far too little is known about the effects of pollution on the population and the economy and the policy options best able to control it in developing countries. Specifically, economic and environmental officials must have access to the following kinds of information before choosing the specific technical and policy controls that are cost-effective: the quantities and nature of the pollutants, the extent of the health hazards posed by each technological control option, the policy control options, and a systematic approach to evaluate the political and economic consequences of adopting a pollution control policy.

Based on discussions with the Turkish authorities, the following factors may explain Turkey's reluctance to adopt aggressive pollution control measures: (i) the belief that environmental and economic development goals are incompatible; (ii) the high investment costs of some pollution control measures in conditions of scarcity of foreign exchange, and competition for scarce capital within the country; (iii) the ambiguities surrounding costs of pollution in terms of health hazard and overall reduced welfare as separate issues from the effects of widespread poverty; (iv) missing or ineffective economic incentives and institutions - governmental, legal, economic, and social -- to support pollution reduction policies.

The potential constituency in favor of air pollution control is weakly identifiable and poorly informed of the causes, possible effects, and available technological alternatives. In contrast, those against pollution control enforcement are economically powerful and politically well organized. In some cases, because of the lack of information, or understanding of complex causal relationships, even relatively low capital outlay measures such as better current maintenance of motor vehicles and equipment are missing because their application could entail complex behavioral and institutional changes.

While the present paper is a diagnostic of the status-quo, it identifies gaps in present information and it offers in the Annex a methodology to answer the following questions:

(i) Is there a cost-effective solution, other than "end of the pipe" pollution control which involves adopting modern plant, equipment and improved processes, paralleled by lower demand for energy, which could meet both environmental and development objectives?

(ii) What are the macroeconomic and institutional regimes needed to establish a system of incentives to make the environmentally benign technology attractive to industry and acceptable to the population?

II. ECONOMIC BACKGROUND

Beginning in 1980 Turkey embarked on a fundamental economic transformation. The objectives of the policies adopted were two-fold: first, to recover from a severe economic crisis, and this was successfully accomplished by 1984-85; second, to encourage rapid economic growth by redirecting the economy toward greater reliance on market forces and the private sector. This has been constrained recently as inflation increased to the 70 percent range by early 1988 following a period of fiscal expansion. Growth fell to 1.7 percent in 1989. In response to this situation, current policies emphasize the need to increase export earnings, and to reduce inflation over the medium-term through fiscal restraint and further import liberalization. These macroeconomic policies could affect the country's ability to invest, adopt or import clean technologies for energy supply, for public transport, or for environmental monitoring.

The macroeconomic policies adopted in the last nine years affect both the rate of growth and the structure of the economy as a whole and of the energy sector. The level of energy consumption and the technology used to generate it determines the types and quantity of pollutants emitted into the air. Income levels by major consumer groups in society affects their ability to pay higher prices for cleaner fuels for domestic heating and transport.

The pollution control policies which the Government might eventually adopt will depend on the severity of the effects of major pollutants on the health of the urban population, structures and vegetation relative to (i) the direct economic costs of alternative technological options (ii) the welfare effects as a result of possible changes in consumption levels and patterns, as the prices of energy and transport change with internalization of environmental costs; and (iii) on the administrative cost of implementing the pollution control policy and its potential impact on the public investment and operating budget.

The objective of the present paper is to identify the key sectors and potential links that should be investigated in the future to formulate a set of cost effective air pollution control policies for Ankara. For more detailed discussion of possible relationships between macro-economic and environmental policies, see the Divisional Working Paper No. 1989-6: "Sustainable Development: Issues in Adjustment Lending Policies" by I. Sebastian and A. Alicbusan.

Consumption of energy in Turkey is expected to grow as a function of the overall growth in GDP and the population growth rate: Economic Surveys (1986/87) of the OECD estimate that Turkey had a 5.5 percent GDP growth rate and a 2.2 percent population growth rate for 1981-87; the World Bank estimated in its Energy Sector Adjustment Loan report of June 1987 that energy demand in Turkey will continue to grow at about 5.4 percent and the IEA estimated that for the period 1985-1990 the elasticity of energy demand with respect to GNP will be higher than 1 (Tables 1 and 2).

Table 1

TURKEY

COMPOSITION OF ENERGY DEMAND BY TYPE OF ENERGY - 1983
(1000 Tons of Petroleum Equivalent)

	SECTOR								
Type of Energy	Agriculture	Industry	Transportation	Heating	Power Plants	Gas	Non-Energy	Refinery	TOTAL
Petroleum and Derivatives									
Petroleum products >									
Gasoline >									
Diesel >									
LPG >	1,360	4,275	5,868	1,814	1,990	11	517	979	16,814
Fuel oil >									
Kerosene >									
Jet fuel >									
Hydro					2,839				2,839
Natural gas		7							7
Electricity Imports					556				556
Hard coal		2,591	146	40	273	158			3,208
Lignite		1,332	40	2,097	2,128				5,597
Animal and vegetable waste				3,574					3,574
Fuel wood				5,126					5,126
TOTAL	1,360	8,205	6,054	12,651	7,786	169	517	979	37,721

Source: Japan International Cooperation Agency, 1986: The Study on Ankara Air Pollution Control Project.

Table 2

TURKEY

COMPOSITION OF ENERGY DEMAND BY TYPE OF ENERGY, - 1989
(1000 Tons of Petroleum Equivalent)

	SECTOR								
Type of Energy	Agriculture	Industry	Transportation	Heating	Power Plants	Gas	Non-Energy	Refinery	TOTAL
Petroleum and Derivatives									
Petroleum products >									
Gasoline >									
Diesel >									
LPG >	1,574	6,580	8,320	2,540	2,020	75	1,780	1,200	24,069
Fuel oil >									
Kerosene >									
Jet Fuel >									
Hydro					5,800				5,800
Natural gas		632							632
Electricity Imports									
Hard coal		4,518	30		430	85			5,063
Lignite		2,306	50	2,740	5,504				10,680
Animal and Vegetable Waste				3,158					3,158
Fuel Wood				5,344					5,344
Solar				2					2
Geothermal					23				23
TOTAL	1,574	14,016	8,400	13,784	13,657	160	1,780	1,200	54,571

Source: Japan International Cooperation Agency, 1986:
The Study on Ankara Air Pollution Control Project.

Changes in the structure of the economy are expected to affect both its average energy intensity and the areas of the country where demand originates. In particular, the shift in economic activity from agriculture to industry, and within industry toward the development of capital goods production which are energy intensive, has brought the share of the energy intensive intermediate goods producing industry to up to 40 percent of total production of the manufacturing industry, as reported by the State Planning Organization (SPO) in the five years development plan.

Overall, while the share of the residential sector in total final demand for energy dropped from 49 percent in 1975 to 45 percent in 1985, the share of the industrial sector increased from 22 percent to 29 percent over the same period (World Energy Conference, 1986, Izmir).

The change in the structure of the economy from agriculture to industry, apart from its effect on the level and pattern of energy consumption raises the possibility that Turkish industry might be able to meet potential demand for pollution control and abatement technology and for energy efficient consumer goods. The impact on welfare and on direct economic cost resulting from pollution control abatement policies will differ according to which local industry has the capacity, know how, and potential to produce catalytic converters for transport vehicles, insulation and energy efficient materials and appliances for the construction and consumer goods industry, or to operate and maintain modern plant equipment for power generation and supply. Analyses of the energy, industry, and transport sectors should be integrated within the methodological framework presented in Chapter IV to evaluate the relative costs of alternative pollution control policies that could be applied in Turkey to meet acceptable air pollution standards.

Changes in demography, and, specifically, the increased rates of urbanization account for concentration of the demand for energy for household consumption in the urban centers. Urban concentrations account for both higher demands for the production of energy and for increased incidences of health effects among the populations living close to the area of energy generation, as more people are exposed to the by-products of burning fossil fuels. Based on the analysis of the data produced by previous studies, the mission has estimated the secondary energy demand in 1983 for the city of Ankara, the energy demand in 1983 and 1995, and the associated emissions from combustion expected in 1990, assuming that no pollution control measures are taken (Tables 3, 4, 5).

Supply of energy in Turkey has two main characteristics: first, it relies on fossil fuels for its resource base, mainly imported oil and its derivatives, lignite and imported hard coal (Table 1); and, second, its production and delivery are dominated by state economic enterprises, the electricity authority and the coal mining authority, under the administration of the Ministry of Energy. Lately Turkey is turning toward natural gas as a fuel for energy production. The price of energy to consumers, except for petroleum products' prices, do not reflect the economic costs of supply. The prices of the inputs used in production, the cost structure of the enterprise and its management structure affect, other things being equal, the mix of factors and the type and quantity of resources that the industry use to generate energy.

Table 3

SECONDARY ENERGY DEMAND BY SECTOR - 1983
Energy Delivered to the End-Users: Electricity, Petroleum Products, Fuel, Gas, and Charcoal
(1000 Tons Petroleum Equivalent)

	TURKEY		ANKARA	
Sector	Quantity	Percent Share	Quantity	Percent Share
Agriculture	1,509	(4.0)	53	(1.6)
Industry	10,939	(29.0)	580	(17.4)
Transport	7,092	(18.8)	525	(15.7)
Heating	16,824	(44.6)	2,089	(62.7)
Non-Energy	1,358	(3.6)	87	(2.6)
TOTAL	37,722	(100.0)	3,334	(100.0)

Assumptions: Total energy consumption is equivalent to primary energy demand for 1983.

The sectoral energy consumption in Ankara is equivalent to the proportion of that sector in Ankara relative to that for Turkey as a whole.

Source: Environmental Problems Foundation of Turkey, 1989. Air Pollution Study - Turkey; Japan International Cooperation Agency, 1986. The Study on Ankara Air Pollution Control Project.

Table 4

ENERGY DEMAND IN ANKARA FOR YEARS 1983, 1995

Type of Energy	Units	Year 1983 Amount	Year 1995 Amount
Petroleum Products			
Gasoline	$\times 10^3$ ton	155	208
Diesel	$\times 10^3$ ton	283	340
LPG	$\times 10^3$ ton	68	150
Fuel oil	$\times 10^3$ ton	226	380
City gas	$\times 10^6$ m^3	65	80
Electricity	Gwh	1,093	3,100
Coke	$\times 10^3$ ton	160	124
Lignite	$\times 10^3$ ton	1,000	1,270
Briquettes	$\times 10^3$ ton	15	13

Source: Japan International Cooperation Agency, 1986. The Study on Ankara Air Pollution Control Project.

Table 5

ESTIMATED EMISSIONS FROM COMBUSTION SOURCES - ANKARA - 1990
(Tons/Year and Percent)

SOURCES	SPM	SO_2	NO_x	HC	CO	TOTAL
	POLLUTANT					
Transport	1,160	870-3,151*	25,290	54,000	311,650	392,970-395,251
Percent (%)	(6)	(1-6)	(87)	(91)	(92)	(77-78)
Household 1/	20,100	56,500-58,510*	3,650	5,700	27,700	113,650-115,660
Percent (%)	(94)	(96-98)	(13)	(9)	(8)	(22-23%)
TOTAL	21,260	57,370-61,661	28,940	59,700	339,350	506,620-510,911

1/ Space heating.

Note: Where two values are given for a pollutant, it represents the range of values obtained using the two sources given below.

* Emissions during winter months - 1984-1985.

Source: Environmental Problems Foundation of Turkey, 1989. Air Pollution Study - Turkey; Japan International Cooperation Agency, 1986. The Study on Ankara Air Pollution Control Project.

So far, in order to reduce air pollution in Ankara, and, taking into account of the balance-of-payments situation, the Government of Turkey searched for technologies that allow the use of the domestic low caloric value and high sulphur content lignite as a substitute for oil. At the same time concerned about the environment, the Government takes advantage of the relatively low cost coal on the world market and is substituting low imported sulphur coal for the domestic lignite. The narrow revenue base in the Government budget accounts for measures to cut selectively subsidies for both the production and distribution of electricity, as well as some forms of consumer subsidies; by cutting all tariff subsidies to the aluminum and ferrochrome industries which are heavy consumers of electricity, both public expenditures are reduced, and consumption of electricity is brought down. This is an instance where policy measures taken to restore economic balances have positive environmental consequences. Petroleum prices are set at or above the import parity level and, relative prices of diesel fuel and gasoline are brought in line as part of the policy measures instituted to conserve energy (World Bank Energy Sector Adjustment Loan, 1987).

To improve the management performance of the sector and reduce public spending for energy production, the Government proposes to encourage private sector participation. It instituted measures to eliminate statutory barriers to competition to attract private finance for electric power and lignite firing for power generation, and energy state enterprises are to be allowed to share ownership with private firms. The Government is encouraging foreign participation in the sector by allowing them to build and operate for a time the power plants in Turkey, after which they can be transferred to national entities.

Policies and measures taken to save energy affect the expected levels of emissions and the ambient air quality, and incentives can be utilized to encourage the adoption of the least-cost, environmentally acceptable technology to meet the needs for household energy consumption and for transport in the city of Ankara. The following questions will have to be tested and investigated in the future: can dissemination of consumer public information in combination with changes in the prices of complementary goods and services needed for energy conservation lower energy consumption by city households?; which price changes, including fuel prices, tariff adjustments on pollution control technology, cost of financing new non-polluting technology, can be best to assure a cost-effective way to meet demand for energy and transport without arising the health risk of the population.

III. AIR POLLUTION SITUATION IN ANKARA

A. PHYSICAL, INSTITUTIONAL, AND SOCIAL CONTEXT

Physical Characteristics

The city of Ankara, with its unusual combination of topographic, climatic and demographic characteristics, is especially prone to high levels of air pollution and their attendant adverse impacts.

Ankara is located in Central Turkey (40° N latitude, 33° E longitude) on the Central Anatolian plateau. It is surrounded by hills and highlands varying in height from 1050-1500 m above sea level on all but its western side. The city itself lies in a basin at an elevation of 750 to 1000 m above sea level with an average elevation of approximately 900 m. The total area of the metropolis of Ankara is approximately 3,395 km^2 but rapidly increasing population growth has pushed the environs of the city farther from the center, especially along its western basin.

The climate of Ankara is typical of a continental region with cold, semi-moist winters and hot, dry summers. Temperature variations, both seasonal and daily, are large. Average July temperatures are 23.2° C and January temperatures -0.2° C. The highest and lowest temperature recorded to date are 40° C and -25° C, respectively. Annual precipitation is relatively low with an average of 370 mm. Most of the precipitation occurs in the fall and spring when flooding is possible. Annual mean relative humidity is 60 percent with a winter average of 75 percent. Foggy conditions are common in the winter months with an average of five foggy days/month. Winds are generally calm with an average speed of 3 m/sec and blow predominantly from the north and northeast 54 percent of the time. This topography and climate make it particularly susceptible to atmospheric inversions. When a layer of warm air overlies a cooler, denser surface air mass, it prevents motion and mixing of the atmosphere and there is a greater propensity for high air pollution levels to persist over longer time spans.

Demography

The population of Ankara has grown rapidly since 1923 when it was designated the capital of Turkey. When the first census was taken in 1927, its population was 74,513. Since 1935 the population growth rate has averaged 5.8 percent so that by 1985 it reached 2.25 million. Most of this population growth was the result of migration rather than natural growth. Since 1975, the average population growth rate has stabilized at about 2.5 percent a year. For the entire period between 1927 and 1985 (except for the period between 1975-1980), the population growth rate increase in Ankara has been much higher than that for Turkey as a whole. Also in recent years, the sex and age structure of the population has changed with a general aging of its society (proportion of children below the age of 15 decreased from 40.8 percent in 1973 to 37.5 percent in 1983 and the proportion of females to males increased from 33.8 percent in 1927 to 48.1 percent in 1980).

The population distribution shows that the highest density is in the center of the city which coincides with the lowest point of the Ankara basin and averages 155 persons/ha. This is also the area where air pollution levels are the highest. Most of the low-income communities are located in the northern and eastern parts of the city in areas known as gecekondus (settled overnight) districts. These areas were populated without any regard to zoning plans; thus they are situated on low or sloping lands not conducive to settlement. One result of these unplanned gecekondu settlements is that they are located on sloping north-south valleys, thus clogging channels which formerly ensured the flow of air from the Ankara basin. Although most of the population increase has been confined to the existing topographical basin, future increases would have to be distributed outside of this region, especially along the mountainless western boundaries.

Economic Activity and its Location Throughout the Metropolitan Area

Ankara is predominantly a government center and does not have significant numbers of large-scale industries. Still, there are some large industrial plants like the Ankara Cement Factory, a number of asphalt preparation plants, a sugar and gunpowder factory, and two city gas plants. The majority of these are large point sources of pollutants and are located mostly in the western part of the city. The industrial sector employs approximately 12.5 percent of the working population.

Seventy-five percent of the working population is employed in the social service and commercial sectors. Most of these activities are located in the center of the city, thus giving rise to the highest population density in this area. The residential section of the city is found predominantly in the northern and southern parts. The small agricultural sector employs 4.5 percent of the working population and it is found in the western part of Ankara where the industrial sector is located.

The presence of a central commercial and government core in Ankara has necessitated a transportation network which is radial in pattern and directed toward this central hub. Thus, mobile source emissions of air pollutants are likely highest in this part of Ankara. A simplified diagram of Ankara's transportation network is shown in Figure 1. The total number of motor vehicles in 1983 were 185,107 and are growing at approximately 10 percent a year. Slightly over 73 percent of the motor vehicles are passenger cars, followed by small trucks, trucks, mini-buses, and buses.

The realization that air pollution was a significant problem in Ankara began in the 1960s and coincided with the rapid population increase which occurred at that time. The high levels of air pollutants are the result of three main factors:

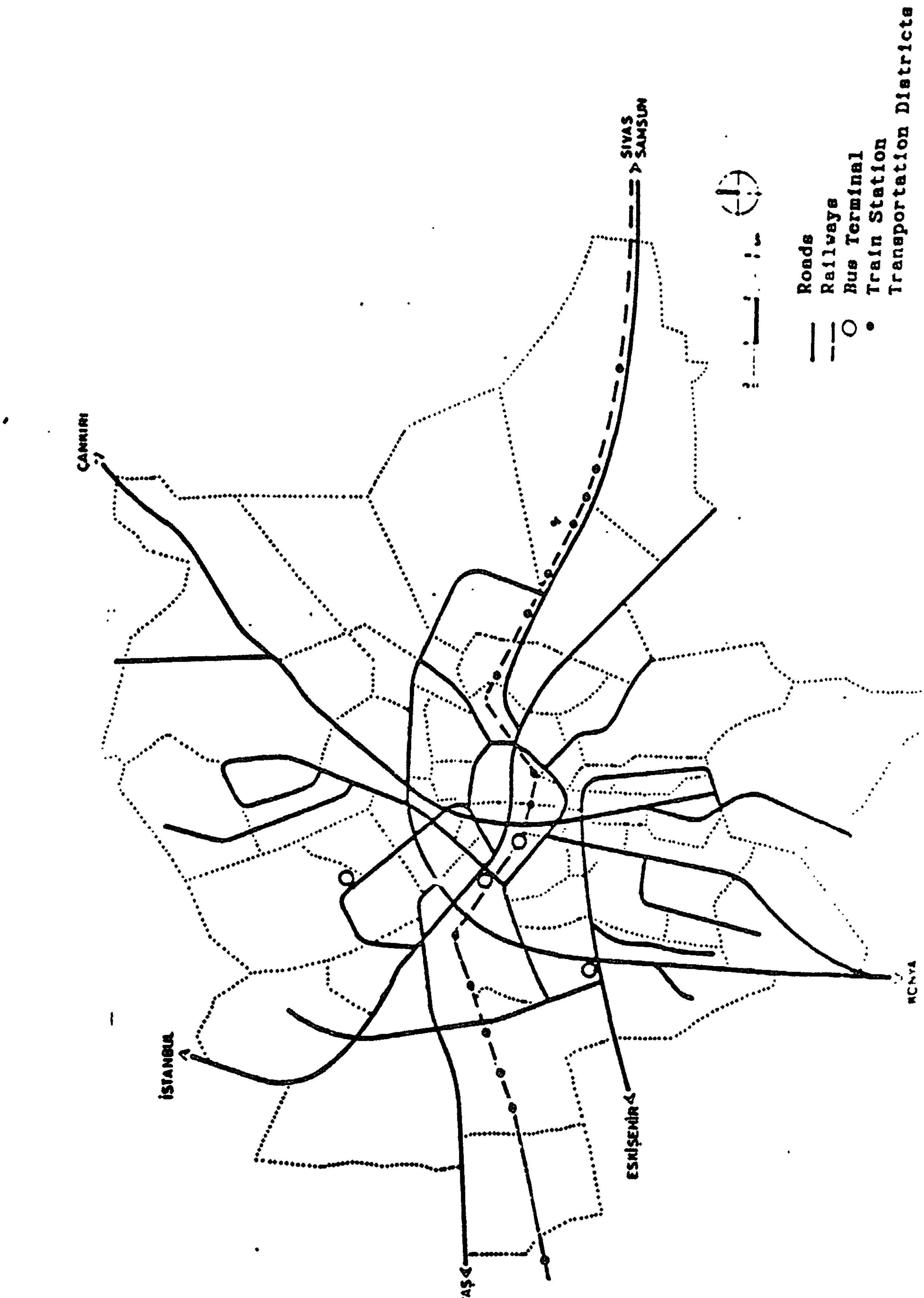
(1) The main fuel used for domestic and commercial heating is Turkish lignite which contains high levels of sulfur and ash.

(2) High population growth and its concentration in the urban setting has led to a rapid increase in the consumption of lignite on a relatively small area.

(3) The topographic and climatic conditions characterizing Ankara are especially conducive to formation of inversions and air stagnation which prevent dispersal of air pollutants.

A program of imported coal is being introduced. According to the Environmental Problems Foundation of Turkey (EPFT), it has had a limited effect on the level of pollution in the city.

Figure 1
Transportation Network - Ankara



The Bank has financed the construction of a high pressure gas supply system and the conversion of the old distribution network with about 100,000 consumers from manufactured gas to natural gas. In a follow-up project, plans for the future include connecting the high pressure supply system to 200,000 additional consumers. This should improve the ambient air quality in the city to the extent that it substitutes for coal burning.

Institutional Arrangements to Deal with Air Pollution

Legislation

According to Government officials in SPO and the Undersecretariat for the Environment, the awareness of the seriousness of the air pollution problem resulted in various legislative/regulatory strategies to address this problem in the city. The major events in the air pollution control process in Turkey and Ankara are the following:

August 1978	Undersecretariat of Environment (U.E.) established under Prime Minister's Office with mandate to develop necessary policies and regulations for rational use, protection and improvement of air and water resources and to take measures to abate environmental pollution.
August 1983	Environment Law - provided legal framework for protection and improvement of the environment, for encouraging development of the country without destroying the environment, and for removal of problems which negatively impact human health and the environment.
June 1984	U.E. - given mandate to develop and implement environmental regulations - authorized to adopt the necessary measures to abate air pollution in cooperation with various agencies and institutions.
November 1986	Regulation for Protection of Air Quality - purpose is to control emissions of soot, smoke, dust, gas, vapor and aerosols into the atmosphere in order to protect humans and the environment - set specific short and long term limits (STL and LTL, respectively) for various air pollutants. These are listed in Table 6.

The Turkish STL and LTL are, in general, less stringent than levels allowed by the U.S., EEC standards, and WHO guidelines. A comparison of limits set by these latter standards with those of Turkey are given in Table 7. In addition to these STL and LTL, the Turkish Government has established target limits for SO_2 and particulates for areas where the STL and LTL are frequently reached and exceeded. These are shown in Table 8. As opposed to the STL and LTL, these target limits are comparable to those allowed in the U.S. and to those set by the WHO and the EEC. However, it is difficult to accurately compare standards of different countries since the averaging times and frequency parameters vary. In Turkey, in particular, there is considerable ambiguity as to what the STL and LTL actually refer since the averaging times and frequency parameters are not clearly defined in the regulation and other documents referring to them give conflicting information. From an analysis of various data, it appears that STL refers to the maximum daily (24 hours) limit and that LTL gives values for average annual maximum levels. However, this needs further clarification.

Another deficiency in the air quality protection program in Turkey is that although the Turkish target limits for SO_2 and particulates are as stringent as the U.S., EEC, and WHO levels, the standards are not actively enforced resulting in concentrations of these pollutants often exceeding the prescribed limits. In addition, although limits are set for a number of substances, active monitoring is carried out for only two of these - SO_2 and particulates. Standards for these other pollutants have little meaning as long as their concentrations are not monitored and emissions are not regulated.

Table 6
Ambient Air Quality Standards

Pollutant	Long-Term Limits (in ug/m³)	Short-Term Limits
$SO_2 + SO_3$		
General	150	400
Industrial areas	250	400
Particulates (10 microns or smaller)		
General	150	300
Industrial areas	200	400
Carbon monoxide	10,000	30,000
NO_2	100	300
NO	200	600
Ozone	-	240 (maximum reference hour limit)
Hydrocarbons	-	140
Chlorine	100	300
HCl	100	300
H_2S	-	40
Lead	2	-
Cadmium	0.04	-

1/ ug/m^3 - micograms/cubic meter.

Table 7
Comparison of Turkish Air Quality Standards with U.S. WHO 1/ and EEC Levels for Selected Pollutants

Pollutant	Standards (ug/m3) Averaging Time 1 hour	24 hour	1 year
SO_2			
US		365	80
WHO	350	125	40-60
EEC	400 (30 min.)	400	80-120
Turkey	900	400	150-250
PM (10 u or less)			
US		260	75
WHO		70	60-90
EEC		300	
Turkey		300-400	150-200
CO			
US	40,000	10,000 (8 hr.)	
WHO			
EEC			
Turkey		30,000	10,000
NO_x			
US			100
WHO	320		
EEC			
Turkey		300	100
Ozone			
US	235		
WHO	120	60 (8 hr.)	
EEC			
Turkey		240	
Lead			
US			1.5 (3 mos.)
WHO			
EEC			2
Turkey			2

1/ WHO values are guidelines rather than standards.

Table 8
TARGET LIMIT LEVELS (UG/M3)

Pollutant	One-Year	Averaging Time Winter (Oct.-Mar.)	24-Hours	1-Hour
SO_2	60	120	150	450
Particulates	60	120	150	-

A commission overseeing the motor vehicle inspection program was established in May 1989. It consists of representatives from the Ministry of Health, the KGM, Ministry of Public Works and the universities. Data emanating from the inspection program will be sent to the Turkish Institute of Standards where it will be available to all interested parties. It is intended that exhaust gas control devices (catalytic converters) will be required on all vehicles to meet CO, HC and particulate standards once the motor vehicle inspection program is in operation, and the conversion to no-lead gasoline is operational. The standards for CO and HC are already prescribed for exhaust gases are as follows:

CO - 2-3 Percent Limit
HC - 220 - 290 ppm.

Although the development and institution of the motor vehicle inspection program and the establishment of emission standards indicates the desire by the government to control motor vehicle emissions, its potential effectiveness in reducing air pollution levels in Ankara is unclear. To be effective, the program needs the following:

(i) control of other pollutants - particularly NO_x + lead;

(ii) information on the contribution of motor vehicles to the air pollution load in Ankara - this contribution may have become significant since 1986 when a large-scale program of converting small vehicles from gasoline to diesel-powered engines was initiated;

(iii) the acceptable limits on exhaust emissions of CO + HC to be expressed on a mass basis (i.e., gm/mi or gm/km) to take into account driving conditions, type and weight of vehicle, exhaust flow rates, etc.;

(iv) be combined with production of unleaded gasoline in sufficient quantities;

(v) institutional means are in place to carry out the inspection program;

(vi) the limit on carbon monoxide emissions from all vehicles in Ankara (2-3 percent limit) should be lowered to be comparable at least to that initially set by the U.S. in 1959 (1.5 percent) for light-duty vehicles. Since then, the U.S. standard for CO has been made approximately 10 times more stringent. Furthermore, the CO standard set by the GDH is more than that currently allowed even for heavy duty vehicles (greater than 2.5 tons) in Japan (CO limit 1.6 percent) and Australia (1.0 percent);

(vii) the Turkish hydrocarbon standard, although within the range of limits allowed in other countries (e.g., Japan, Australia) for heavy duty trucks is still higher than those allowed for passenger cars and light-duty vehicles in most industrialized nations. The HC standard set by the GDH is comparable to the HC standard set by the U.S. in 1959 for light-duty vehicles (275 ppm) but this U.S. limit has since been made 10 times more stringent.

Institutions

Several organizations at various levels are responsible for control of air pollution. The large number of organizations involved in air pollution control in Ankara and the complicated relationships between them have often hindered effective action to address this problem. And, although the administrative and legislative framework necessary to deal with air pollution are in place in Turkey (and Ankara), economic, social, and political conditions constrain their effectiveness. In fact, enforcement activities are very limited. Finally, though technical and scientific knowledge around the world on lowering air pollution caused by fossil fuel burning is considerable, most of this is not directly adaptable to Turkey's major energy resource, lignite.

For those interested in the name of each organization and the specific roles of each in terms of air pollution control in Ankara they are listed on the next two pages.

(1) Central Government Bodies:

(a) The Undersecretariat of the Environment (UE) is the main responsible body and has the authority to deal with air pollution control in Ankara in cooperation with the other organizations.

(b) The Public Health Institute (PHI) is attached to Ministry of Health and Social Affairs is responsible for monitoring of ambient air quality at various monitoring stations and analyzing stack emissions at laboratories; reports the results of monitoring to GDE daily and transferred to Provincial Government of Ankara.

(c) The General Directorate of State Meteorological Works (SMW) is responsible for meteorological observations and weather forecasts - data given to provincial government.

(d) The Ministry of Energy and National Resources (MENR) has two main organizations and one department which deal with air pollution in Ankara:

(e) The General Directorate of Turkish Coal Board (TCI) which is responsible for mining and distribution of coal. Beginning in 1978, they were to supply only best quality domestic coal to Ankara.

(f) The General Directorate of Mineral Analysis and Research (MTA) which is responsible for conducting research on fuels and combustion systems.

(h) The Department of Energy in MENR which is in charge of training boiler operators.

(i) The Ministry of Education, Youth and Sports which is involved in the execution of training boiler operators in cooperation with the department of energy in NENR mentioned above.

(j) The General Directorate of Highways (KGM) which by the 1983 Highway Traffic Act, was given the authority to establish and operate motor vehicle inspection stations. It currently plans to establish a motor vehicle inspection system in Turkey which will measure carbon monoxide (CO), smoke (particulates), hydrocarbons (HC), nitrogen oxides (NO_x) and lead (Pb) levels in exhaust fumes, Private sector involvement is contemplated.

(k) The State Planning Organization (SPO) is responsible for developing and coordinating activities involving economic and social development macropolicies for the country as a whole and with a time frame of five years. It is the principal body involved with integration of environmental policies into these five-year development plans.

(2) The Turkish Council of Scientific and Technical Research (TUBITAK) attached to Prime Ministry. It is in charge of various research endeavors involved with fuels savings in existing buildings and improvement of design for new buildings. The Council funds research on environmental matters and it is planning to set up a committee on Air Pollution Research which will be responsible for coordinating all air pollution studies in Turkey, particularly health-related ones.

(3) The Provincial Government Level is headed by a governor who is appointed by the Minister of Interior Affairs. The directors of various departments in the provincial government are appointed by the relevant central government ministries to the provincial Government. The government and director form the Board of Provincial Administrator (BPA) each year announce specific measures (both normal and emergency) to be taken within Ankara to lower air pollution, and the BPA decides, whether to proclaim an emergency situation, and at what level, based on weather information of SMW and ambient concentrations of SO_2 and PM as measured by PMI and reported by GDE.

(4) The Metropolitan Municipality Level has a number of organizations are involved in air pollution control. These include:

(a) The Directorate of Electricity, Gas & Omnibus (EGO) which is involved in studies on the development of a city gas plant for district heating and on air pollution due to automobile exhausts and their control.

(b) The Ankara Master Plan Bureau (AMPB) which is in charge of master development plan for the Ankara metropolitan area with considerations given to mitigation of air pollution.

(c) The Urban Reconstruction Directorate (URD) which is in charge of implementing the development plan formulated by AMPB, and is involved in approvals of building and construction permits.

(d) The Municipality Police Directorate which is in charge of the inspection of combustion systems, maintenance of boiler systems and newly constructed buildings. They will have authority to require motor vehicle operators to repair vehicles if these are observed to be emitting large amounts of pollutants, mostly smoke.

(5) Non-Government Organizations:

(a) Environmental Problems Foundation of Turkey is involved in problem identification, search for solution, legislative proposals and public education - funded by non-governmental sources - international mostly. This NGO was involved in enactment of 1983 Environmental Law, and has proposed an abatement of Ankara's air pollution problem through the increase of electricity supply and consumption of city gas.

(b) The Turkish Association for Natural Protection is associated with international environmental organizations.

(c) The Turkish War on Air Pollution Association was previously called Ankara Anti-Air Pollution Association. It conducts studies to draw public attention to air pollution in Ankara.

B. AIR QUALITY AND MONITORING

Air Quality

The physical characteristics of the city of Ankara and the burning of poor quality coal (lignite) for domestic heating has resulted in a significant deterioration of air quality over the past decades. The ambient concentrations of SO_2 and particulate matter are often extremely high - several times higher than what is considered to be medically safe. It could well be that the concentrations of other major air pollutants - nitrogen oxides, hydrocarbons, carbon monoxide, photochemical oxidants, lead, etc. - are high as well, but there are essentially no data regarding these.

In the early 1970s, in one of the first evaluations of air quality in Ankara, average SO_2 concentrations of more than 200 ug/m^3 were measured at one-half of the monitoring stations with daily concentrations often exceeding 500 ug/m^3 and even reaching 1000 ug/m^3. For suspended particulates, average concentrations at 4 of the 13 sites ranged from 229 to 370 ug/m^3 with maximum levels ranging from 508 to 1,013 ug/m^3. The next intensive study of air pollution in Ankara (particularly SO_2 and particulates) was conducted during the winter months of 1984/1985 by a Japanese group financed by Japan International Cooperation Agency (JICA). At that time it was determined that average concentrations during a three-month period at seven monitoring sites throughout the city ranged from approximately 350 ug/m^3 to nearly 900 ug/m^3. Maximum 24-hour average concentrations were well above 1000 ug/m^3, and at a few stations approached 2000 ug/m^3.

Concentrations of suspended particulate matter were also high. During this same three-month period the average values at three monitoring stations ranged from 159 ug/m^3 to 227 ug/m^3, with maximum 24-hour readings being slightly above 500 ug/m^3.

WHO guidelines for SO_2 and suspended particulate matter in ug/m^3 are as follows:

	SO_2	Black Smoke	Suspended Particulate	
			Total	10 u or less
1 Hour Maximum	350	-	-	-
24 Hour Maximum	125	125	120	70
Annual Average	50	50	-	-

Comparison of the 1984/85 winter data with the WHO guidelines which have been established for public health protection underscore very clearly the severity of the air pollution situation in Ankara. The maximum daily concentrations as well as the averages are seven or eight times the limits recommended by WHO.

The extent to which health effects are occurring in Ankara due to the high SO_2 and suspended particulate concentration is less clear because of uncertainties in the health effects data and information. There are, however, some general statements which can already be made, as follows:

(a) Effects on mortality are considered to be present when both SO_2 and smoke concentrations exceed 500 ug/m^3 as 24 hour averages and effects on respiratory morbidity have been observed when concentrations of both SO_2 and smoke exceeds 250 ug/m^3 as a 24 hour average.

(b) Decreased lung function is observed, particularly in children at similar concentrations. There is evidence from experiments performed on asthmatic volunteers that SO_2 concentrations above 1000 ug/m^3 increase airway resistance at exercise. No epidemiological evidence has been published concerning the relationships between the occurrence of asthmatic attacks and short-term measured SO_2 concentrations.

Monitoring of SO_2 and suspended particulate matter has continued, but the results have not been fully analyzed. A review of the results for January and February of 1989 provides a glimpse of the situation in 1989. For these two months the monthly averages of SO_2 ranged between 250 ug/m^3 and 522 ug/m^3 with maximum daily concentrations being 700 to 800 ug/m^3; in one location a maximum concentration of 1153 ug/m^3 was phenomenal observed. For suspended particulates the average concentrations still exist, even after the replacement two years ago of the poor quality lignite by "better" coal which is being imported. During this period WHO guidelines for sulfur oxides of 125 ug/m^3 was exceeded from 85-100 percent of the time at the seven monitoring stations.[1]

Some studies have been made of the metallic compositions of the particulate matter, e.g., lead, cadmium, etc. The results showed monthly average lead concentrations, for example, ranging from 0.2 ug/m^3 to 1.4 ug/m^3

Air quality information on other pollutants is essentially non-existent. Some measurements of CO, NO_2, and HC were made in 1982/83 but the data are not readily available. Some measurements of these pollutants were also made in 1970/71, but the increase and change in car population since that time make these measurements irrelevant.

No studies at all have been made of the pollutant concentrations indoors. Also, no studies have been made of human exposures to any of the pollutants.

It can be stated that air pollution levels in Ankara, particularly in the winter months, are within the concentration ranges observed in London in the 1940s and 1950s. In London, peak concentrations of SO_2 and particulates often reached over 2000 ug/m^3 with average levels in winter close to 1000 ug/m^3. The health effects under such circumstances showed increased mortality rates at SO_2 levels of 500-1000 ug/m^3 (24 hour mean) with particulate concentrations of 500 ug/m^3. Mortality effects were particularly severe if both SO_2 and particulates reached over 750 ug/m^3. Increased aggravation of bronchitis was observed at SO_2 concentration between 500 and 600 ug/m^3.

However, in both London and Ankara, interaction with other pollutants must also be considered when assessing health impacts of SO_2 and particulates. In London, the presence of fog (high relative humidity often

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1/ The Japanese study conducted in 1984/85 showed that the monitoring data which was being collected in Ankara at that time using semi-automatic sampling devices were considerably in error due to faulty instrumentation and techniques. This was corrected by the introduction of some new instruments and changes in the techniques for others. Although no checking of the validity of the currently produced data was possible at the time of the visit in Ankara, it was noted that for SO_2, calibration was carried out using standard solutions only, rather than the more comprehensive and reliable dynamic calibration procedure.

approaching 100 percent) may have aggravated the impact of high levels of SO_2 and particulates. On the other hand, levels of other pollutants (NO_x, ozone, and HC) were not measured in London at that time. In Ankara, the relative humidity, although high, 75 percent in winter, is not as high as in London; however, it is possible that concentrations of NO_x, ozone and HC are higher than was in the London of the 1940-1950s. The interactive effects of various pollutants and meteorological conditions and their effects on the city's population health and welfare need further investigation.

Monitoring Capacity

The monitoring of air quality in Ankara is the responsibility of the Public Health Institute (PHI) of the Turkish Ministry of Health. The data which are collected are provided normally to the General Directorate for the Environment, Municipality of Ankara and others. The current possibilities for monitoring SO_2 and suspended particulates in the Ankara area appear largely satisfactory - there are a sufficient number of stations, adequate instrumentation and sufficient experience on the part of the staff to perform the necessary sampling and analysis. For other major air pollutants monitoring instrumentation is lacking and the staff has very limited experience in dealing with them. In order to be able to measure the presence and concentrations of NO_x, hydrocarbons, carbon monoxide, photochemical oxidants and lead, monitoring instruments and staff training will be needed.

C. SOURCES AND EMISSIONS OF POLLUTANTS

Current information on air pollution sources and emissions in Ankara is mixed. There is some recent information on the emissions of sulfur oxides, but it lacks specificity and detail. There is no information on sources of other pollutants, namely particulate matter, oxide of nitrogen, hydrocarbons, carbon monoxide and lead. The only available data dates back to 1969.

In 1984/85, combustion of coal and lignite for heating residential and commercial buildings and for industrial purposes accounted for nearly 90 percent of SO_2 emissions. Motor vehicles and other transportation sources are relatively negligible sources of SO_2. SO_2 sources are dispersed throughout the city as the emissions come from hundreds of thousands of household chimneys.

During the winter of 1984/85 an estimated 60,000 tons of sulfur oxides were emitted into the atmosphere with 45,000 tons coming from the burning of ungraded lignite. This quantity of SO_2 emissions for the winter months alone translates to a SO_2 emission/deposition density for Ankara of 180 kg/ha, thus ranking it among the highest in the world. In 1987, much of this lignite (high in sulfur, dried ash, and low heat value) was replaced by the importation of improved coal from South Africa and China. No calculations have been made on the amount of SO_2 emitted since the combustion of the imported coal was started and air quality monitoring data shows only marginal declines in SO_2 levels since the conversion. (Comparison of imported vs. domestic coal (lignite) characteristics is given in Table 9).

As regards the other pollutants, with the exception of lead, for which there is no information, the only information available dates from 1969. While the number of sources and amounts of emissions of these pollutants have increased considerably since then, the pattern of distribution by source category is likely to remain in the same range. These relative contributions are shown in Table 10.

The Environmental Problems of Turkey Foundation has estimated though, that approximately 500,000 tons of pollutants from combustion sources, i.e., transportation exhaust and stack gases from space heating are emitted annually into the atmosphere over Ankara.

Table 9
Comparison of Turkish Lignite and Imported Coal Characteristics

	Sulfur Content (percent)	Volatiles (percent)	Ash (percent)	Heat Content (Kcal/kg)	Moisture (percent)	Cost (TL/ton)
Turkish Lignite	2 (1-6)	17-20	16 (10-41)	2800-4500 (1000-5750)	15-30 (3-50)	14,000
Imported Coal	0.8-1.0	20-24	4.5-6.5	6000	8	120,000

Note: Figures in ( ) are ranges.

Table 10
Relative Contribution of Emissions (percent)

	Particulates	CO	HC	NO_x
Motor vehicles	2	77	62	44
Stationary fuel combustion	79	12	12	52
Refuse disposal	5	8	12	3
Industrial process	14	3	-	-
Evaporative losses	-	-	11	-

D. HEALTH EFFECTS AND OTHER IMPACTS OF AIR POLLUTION

Air pollution in Ankara reached levels which can be expected, based on available information elsewhere in the world, to have an adverse influence on human health during the winter season. Although this has been the case for long, only limited studies have been performed concerning health effects of air pollution in the specific living conditions and life styles prevailing in Turkey and specifically in Ankara. Without such direct evidence it is not possible to ascertain which are the health risks to which the Ankara population are subjected at various ambient air quality levels.[2]

Some studies concerning health effects of air pollution in Ankara have been performed in the past.[3] These studies include observations of correlations between measured SO_2 and total suspended particulates (TSP) concentrations and diminutions of respiratory function measured and they point to statistically significant differences between boys in Ankara City and boys in control area, Cubuk.

Additional studies on the health effects of air pollution are necessary to identify which types of pollutants have the most deleterious effects on human health, and function of these findings to allow a prioritization of the programs to be undertaken to lower the health risks. Because health effects in Ankara can be related to measured levels of pollutants (e.g., NO_2), which were not measured in previous epidemiological studies, the additional studies have the potential to improve our scientific database concerning dose-response relationships for health effects.

Opportunities to study relationships between air pollution and health in Ankara have been utilized only to a limited extent. However, good facilities for clinical and epidemiological studies are available particularly at the Hacettepe University, Department of Chest Disease and Department of Public Health. These facilities could be combined with the air pollution monitoring at the Public Health Institute (Refik Saydam Central Hygiene Institute) data emanating from the motor vehicle inspection program, and quality assurance programs supported by METU to carry out epidemiological research of high scientific standards.

(a) Clinical Observations and Lung Function Measurements in Children

Professor Sakir Tanindi and associates at the Gulhane Military Hospital, Department of Pediatrics, Ankara, has performed a study of 600 school children aged 6 to 14 living in Ankara and a control group of 112 school children, living in Golbasi, a district outside the city area. The

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2/ For a review of the methodology to estimate health effects of ambient air pollutants see Environment Department Divisional Working Paper No. 1990-11 by Krupnick and Alicbusan.

3/ A review is found in a report (TUR/RCE/QQ2/Ex/TUR/CEP); UNDP/TUR/77/022) by Schlipkoter 1978.

findings were as follows: (a) persisting coughs during winter; (b)a difference in the prevalence of bronchitis between the two groups of children; (c) the prevalence of pneumonia was increased in Ankara school children relative to the control group; (d) pulmonary function (FEV.1) values of children were significantly decreased in families with more than 1.5 persons per room; (e) and in families where both parents are smokers, VC and FEV.1 of children were significantly decreased compared to controls ($P < 0.05$).

These studies were performed during 1982 and 1983 a period of severe air pollution situation in Ankara, when many clinical cases of respiratory disease were observed among children. The studies on school children could be repeated, following the children longitudinally with repeated lung function measurements at the Gulhane Military Hospital. This would allow a comparison with simultaneously monitored air pollution levels at the Public Health Institute to assess the importance of present air pollution levels on the health of children. The results would be of considerable general scientific value, if correlations with measured air pollution levels can be found.

(b) Lung Function in Adults

At the department of Chest Disease and Tuberculosis, University of Ankara (Professor Karabiyikoglu), a study has been performed on volunteers who had lived in Ankara for various lengths of time. The excellent facilities for lung function studies available at this department had been utilized in these studies. For some of the measurements, differences with statistical significance were reported between smokers and non-smokers, when residence time in Ankara exceeded 10 years. A problem in the comparison was that groups with specified residence time were not standardized for age and body size. Further analysis could be done,since the original data base is still available.

An epidemiological study of daily morbidity in respiratory disease in Ankara (based on daily admission records to major hospitals) related to measured daily air pollution levels could be performed as a joint project by these institutions. In addition to the conventional air pollutants, information on short term (1h) NO_2 and O_3 concentrations could be collected. This study has a potential of contributing new data on possible epidemiological relationships between acute respiratory effects and short term (1h) SO_2 and NO_2 concentrations, which are very scarce or nonexistent in the scientific literature.

(c) Incidence of Respiratory Disease in Ankara

According to data from the Ministry of Health, (Dr. A.T. Celebioglu), there were between 21,926 to 26,089 cases of unspecified acute respiratory infections per year (total of discharged and dead) in Turkey 1982-86. Influenza occurred in 11,096 to 13,260 cases, viral pneumonia in 3,478 to 5,033 cases, and other pneumonia in 41,341 to 77,458 cases. For Ankara the corresponding numbers for 1986 were: 1,337 (acute respiratory infections); 365 (influenza); 223 (viral pneumonia); 1,949 other pneumonia.

The diagnosis "Bronchitis, emphysema, and asthma" represented between 38,896 and 64,018 admissions to hospitals (total number of patients discharged or dead) in Turkey during the years 1982-86. Of these cases, between 515 to 859 died. In Ankara, 2,270 patients were admitted with these diagnoses out of a total of 64,018 for Turkey. It is not possible to state, at present, whether respiratory disease is more prevalent in Ankara than elsewhere in Turkey.

Morbidity data routinely collected from all hospitals in Turkey by the Ministry of Health is presented on a yearly basis, with the potential to be broken down on a three-months basis. This would allow to examine if cardiovascular and respiratory morbidity and mortality could be statistically correlated with air pollution concentrations averaged over a similar time period.

(d) Cancer Incidence and Mutagenicity

Only very limited evidence is available in the literature on a possible relationship between mutagenicity of air pollutants and the incidence of respiratory cancer. A role of asbestos minerals in inducing lung cancer and pleural mesotheliomas is established in the occupational setting; however, other environmental exposures are less well established as a cause of such disease.

A study of the geographical distribution of respiratory cancers in the greater Ankara region is also needed to examine a possible relationship to measured air pollution levels as averaged over many years (and possibly to some extent related to mutagenicity which is only available since last year). Factors that need to be considered in such a study are potential differences in age distribution and smoking habits between different parts of the city and the surrounding area and possible differences in reporting respiratory cancers.

The studies of mutagenicity of air pollution in Ankara performed at METU, Department of Biology could be continued and complemented by studies of human urinary mutagenicity, indicating exposure to mutagens. Persons with particular exposure to air pollutants (e.g., bus drivers), working and living in parts of the city with different mutagenicity of air pollutants may be compared. Such a study could be standardized for smoking habits and become of importance for evaluation of potential cancer risks posed by air pollution in Ankara. There are possibilities to expand the mutagenicity program by obtaining samples from air pollution in another Turkish city, e.g., Eskisehir, where lignite is still used for domestic heating to estimate if shifting from the use of lignite for heating has a significant health impact.

(e) Cancer Caused by Fibrous Materials

At the Department of Chest Disease, Hacettepe University (Professor Izzettin Baris), a series of important observations have been made concerning lung disease caused by fibrous materials.

In a recent monograph, Prof. Baris has summarized current knowledge in this field, pointing out that non-occupational, environmental exposure to these minerals present substantial risks for development of malignant pleural mesothelioma (an incurable form of malignant chest disease) and lung cancer. Particularly in the villages Karain, Tuzkoy, and Sarihidir, exposure to erionite minerals is high. Although exposure to these minerals does not occur in Ankara, patients from the villages are treated at the hospitals in Ankara and the inclusion of such cases should be carefully screened as they may influence the result of studies based on patients at these hospitals.

(f) Mutagenicity

In recent years mutagenicity as measured by the Ames' Salmonella Assay has been increasingly used as an indicator of the potential genotoxic hazard of air pollution. In an ongoing project at the Department of Biology, Middle East Technical University, Ankara, Associate Professor Hasan Bagci, is measuring mutagenicity of Ankara air pollution as sampled in the monitoring program at the Environmental Health Research Laboratory, Ankara. The mutagenicity of Ankara air was found to be higher than in other major cities in the world where such measurements have been made. Differences were detected between different parts of the city of Ankara.

(g) Cancer Incidence

Cancer is a notifiable disease since 1983 and the number of reported cases in Turkey has increased from 9,868 that year to 19,304 (1987). Still, it is obvious that the reporting is far from complete. Data up to 1987 has been published by the Cancer Prevention Department of the Ministry of Health. Respiratory cancers constitute the largest group of cancers in all regions of Turkey.

(h) Lead Uptake from Air Pollution

At the pharmaceutical faculty, Ankara University (Professor Nevin Vural), blood lead concentrations were determined by atomic absorption spectrophotometry among 430 persons, not occupationally exposed to lead, living in the city center of Ankara for more than 10 years. The mean blood lead concentration in this group was found to be 16.5 ug/100 ml, significantly higher than the concentration in a control area (Golbasi) where the mean concentration was 10.5 ug/100 ml. Since leaded gasoline is still used in Turkey, it is of importance to continue to follow lead levels in blood in Ankara's inhabitants.

It is important to continue biological monitoring of lead exposure by means of blood analyses by atomic absorption spectrometry as performed at the pharmaceutical faculty, Ankara University. Further analysis should assess the level of human exposure by blood lead determinations in a sample of inhabitants of Ankara living in one of the sections of the city where traffic is heavy and to compare it with an area outside the city. An external quality assurance program would be necessary so as to make sure that measured levels can be compared to results obtained elsewhere.

Effects of Air Pollution on Agriculture, Forests and Aquatic Ecosystems, Visibility, and Materials

Very limited information is, so far, available on the impact of air pollutants on vegetation, animals, aquatic ecosystems and materials. Not much attention has been focussed on this aspect of air pollution as most of the research undertaken to date was concerned with effects on health. With this in view, air pollution monitoring and assessment activities have been assigned to the Ministry of Health (Public Health Institute), rather than to the Undersecretary of the Environment.

(a) Agriculture

The average ambient concentration of SO_2 in Ankara is high enough to pose a threat to agricultural crops. However, because the extreme peak levels occur mainly in the winter months when crops are not grown and because relatively few large-scale agricultural activities occur within the Ankara city limits, the potential for significant damage to crops by Ankara's air pollution is limited. Ozone may be a greater threat to crop growth as it reaches peak levels during the summer growing season. In addition, ozone has been well documented as causing significant damage to a variety of commercial agricultural crops.

(b) Forests

As is the case with agricultural crops, sulfur dioxide levels in Ankara are high enough to be able to damage a variety of tree species, but, because most of the local trees are dormant during the winter and there are relatively few trees to begin with, potential effects are limited. Ozone may pose a greater risk to forest and tree growth and survival.

(c) Aquatic Ecosystems

There are no significant aquatic ecosystems within the city limits of Ankara.

(d) Visibility

Impaired visibility is another negative effect of air pollution. Although direct measurements have not been made, it is evident that visibility has been reduced due to deterioration of air quality over the past few decades. Reduction of visual range has significant aesthetic and recreational/cultural consequences, but its greatest risk lies in its impairment of driving and flying conditions.

(e) Materials - Built Structures

The existence of high concentrations of SO_2 and particulates and an abundance of buildings made of pollution sensitive materials such as marble, steel, stone and concrete present significant risks in Ankara. In addition, the combination of high levels of SO_2 (and possible of NO_x) and relatively high relative humidity (60-75 percent) and frequent occurrence of fog increases the likelihood of the existence of acidic disposition which is especially damaging to built structures and other materials such as paint, textiles, leather, metals, rubber, and ceramics.[4]

It should be noted that replacement and damage costs do not include nonmonetary values such as those connected with historical, aesthetic or religious significance. Also, visibility impairment is not easily translated into monetary terms. Moreover, material damage costs are usually unreliable and contain many uncertainties due to a number of reasons, amongst which we highlight the following:

The difficulty in isolating and determining the specific damage caused by air pollutants vs. other environmental and non-environmental factors (general aging and wear-and-tear on materials); exposure assessments are often inaccurate due to sheltering and orientation of materials which are usually site-specific and thus must be considered on an individual basis; there is no inventory of materials and their vulnerability to air pollutants - structures often made of variety of materials with varying degrees of sensitivity to air pollutants; lack of information on possible (usually more expensive) substitutes which could better tolerate air pollution; and

The complexity of air pollution damage dependent on other environmental/meteorological conditions, such as relative humidity, temperature, wind speed, topography, and precipitation; and the level of accuracy of environmental/meteorological data particularly ambient air quality measurements and concentrations of various pollutants.

IV. FINDINGS AND RECOMMENDATIONS FOR FURTHER STUDY

Based on the available information, we are concluding with the following observations:

4/ The cost of air pollution damage can be estimated in a variety of ways, including:

(1) General cost of damage:
= Quantity of vulnerable receiving surfaces X value of each X extent of damage (air pollution damage function).

(2) Cost of replacement:
= Quantity of material affected X cost/unit to replace, clean, or paint.

(3) Cost of prevention:
Includes costs of additional cleaning and washing of structures, switching to more pollutant tolerant plants, trees and materials, application of protective coatings to man-made materials and covering and shielding sensitive structures from pollutant exposure.

(1) The air pollution problem in Ankara is severe and there are signs of its worsening. The main direct cause is the uncontrolled burning of poor quality coal for the supply of household energy. This has been aggravated in recent years by the rapid growth in the number of vehicles particularly those fitted with diesel engines for private passenger transport.

(2) Control actions have been implemented or are being proposed for dealing with the sulfur dioxide and particulate matter problem, as for instance, importing low S coal and laying a gas line to serve parts of the city. Further analysis is needed to determine how much improvement will be achieved in human exposures and the associated adverse effects on health; or whether, cost- effective alternatives are available for the medium- and long-term. Control or preventive action, sometimes costly action, should not be taken without prior analysis of the situation, and understanding of alternatives and priorities. For instance, there is essentially no information on pollutants other than sulfur dioxide and particulates. The proposed motor vehicle inspection program should improve this situation since it will analyze vehicle exhaust for CO, NO_x, HC and lead. More information is needed on the adverse effects of air pollution in Ankara on health and structures, materials and vegetation. Existing information should be mobilized and used to support control action.

(3) The problems of air pollution should be consistently integrated into the medium- and long-term economic measures to reach development goals; as a rule, air pollution control is viewed as expensive, without clear evaluations or estimates of the alternative costs of developing integrated systems for supplying large cities with energy while meeting acceptable standards of ambient air quality.

(4) While the institutional and regulatory framework for controlling air pollution exist (through the Undersecretariat for the Environment, the Public Health Institute, the Ankara Municipality, and the State Planning Organization (SPO)), overall capabilities should be improved through training and upgrading of equipment. Better use of existing resources and widespread application of the results of domestic research efforts could increase the efficiency of pollution control policies.

(5) The municipality of Ankara should proceed with the formulation of alternative strategies for air pollution control, their subsequent evaluation, and the selection of a cost-effective solution. Additional information is needed for a complete assessment of the relative importance of pollutants from mobile and fixed sources and their potential effect on health and other receiving environments. This should provide the technical basis to phase the policies to reduce source emissions.

Information Needs

The following additional information is needed to evaluate options for economically feasible and environmentally acceptable energy supplies for the city.

(a) Further develop methods to evaluate alternative fuel use and other pollution control/prevention strategies vis-a-vis reduction of SO_2 and particulate pollution and their effects on human health. This would entail, for the two pollutants, the updating and refining of the existing source and emission inventory. Modest expansion of the already existing monitoring network, the initiation of indoor/outdoor and personal exposure studies and the improvement of the available air quality models for Ankara. The indoor/outdoor and personal exposure studies would provide information for evaluating which are the most effective and least costly control strategies in terms of their impact in reducing human exposures to these pollutants.

(b) Assess the severity and extent of NO_x, hydrocarbon, carbon monoxide, photochemical oxidants, and lead pollution in terms of their impact on human health. This would entail the preparation of an emission inventory for some of these pollutants, including tapping into the motor vehicle inspection program to analyze automotive exhaust, the gathering of ambient air quality data, the collection of selected human exposure information (e.g., lead in blood, indoor concentrations of NO_2, etc.).

(c) Collect and evaluate information on the health effects of air pollution. This would entail a thorough review of the results of all relevant past epidemiological and other health effects studies, integration, expansion and improvement of the appropriate current or planned studies and the initiation of a few new investigations. While the emphasis will be on Ankara, studies elsewhere in Turkey could be considered as well. This information is needed to monitor public health effects of industrial activity in Ankara and elsewhere and to setting priorities on health care prevention policies.

(d) Develop a method to find cost effective medium and long term solutions to the problems of heating the city of Ankara and its planned suburbs while lowering levels of ambient air quality to ranges acceptable for human health and welfare. This would entail comparing the costs, SO_2 and particulate emissions of various engineering alternatives for supplying the city of Ankara with energy, and testing their sensitivity to policy measures affecting factor input prices. This information is needed to define an appropriate technology to supply the city with energy while maintaining emissions at levels compatible with safe public health.

(e) Analyze current macroeconomic policies, institutions and measures in place and how they can be best used and applied to create the necessary incentives to adopt non-polluting technologies and enhance the application of the solution proposed.

The following Annex proposes a generalized methodology be applied to carry out the suggested environmental analysis.

ANNEX

GENERALIZED METHODOLOGY TO CARRY OUT THE ENVIRONMENTAL POLICY ANALYSIS

The solution to the problem of finding a policy package that allows modernization of the economy while meeting acceptable health norms can be framed in a cost/benefit type of analysis. It affects simultaneously the energy, transport, and manufacturing sectors of economic activity. The analytical questions to be asked fall into three categories: those involving sectoral analysis to determine production costs under environmental constraints, including the social costs of externalities in the form of health effects, policy analysis to estimate the tradeoffs under alternative options of design and implementation of pollution control strategies; and sensitivity analysis to single out the macroeconomic variables (taxes, interest rates, subsidies) to which pollution control strategies are most responsive.

For each sector,the technical solution will have to be associated with a policy control option strategy, which, in turn, translates into specific administrative costs and incentive packages. New investments in alternative technologies or in pollution abatement equipment, pollution charges, added fees, taxes on inputs or on polluting outputs, and differential land taxes, associated with specific pollution control strategies imply resource costs which will affect the costs of production. Such costs will be passed on to consumers or absorbed by the industry depending on the cost structure of the industry, market conditions, and the level of demand. To each control option there are associated the following other costs: enforcement of government control strategy, dead-weight welfare losses and adjustment costs.

Although some of the costs other than private sector and real resources costs are difficult to predict and quantify, they should be considered when estimating total costs to society. The amount of resources devoted to such analyses should depend on the expected contribution of these to total costs. If certain components are likely to be small, less analytical effort should be used to measure them than if they are likely to change the estimated total cost substantially.

Government Regulatory Costs. National, regional, and local governments may incur costs to issue permits for plants affected, to monitor performance, and to enforce compliance.

Dead-Weight Welfare Costs. Net losses in consumers' welfare and producers' supply may occur from the decrease in output of goods and services resulting from a policy control option. Generally, these losses are a relatively small part of the total costs to society, except when there are no readily available substitutes for a product that is banned or that has its use severely restricted.

Adjustment Costs for Displaced Resources. Pollution control policies can result in dislocation of labor and other productive resources. Three types of costs may occur. First, if an industry's production decreases, some of the resources that had been required to produce the lost output fail to be used elsewhere in the economy. Second, there is a resource reallocation cost, typified by a person's spending time and money looking for a job and moving to a new location. Finally, society expends resources to operate programs to help the unemployed (this does not include transfer payments to individuals).

Adverse Effects on Product Quality, Productivity, Innovation, and Market Structure. These elements should be quantified to the extent possible, or at a minimum, discussed qualitatively.

The policy analysis includes costing out each option, estimating the changes in emissions (from an emissions inventory), concentrations (using dispersion models), exposures (correcting for indoor versus outdoor exposures, where appropriate), health effects (using dose-response functions and population data), and benefits (i.e., the economic value of reduced health effects) associated with the control option, as shown in Figure 2.

The cost/benefit or cost-effectiveness analysis, whose flow chart is presented in Figure 3, involves a comparison among alternative policies. In the absence of health benefit values environmental goals can be set exogeneously as measures of the effectiveness of the policy (such as meeting air quality standards) and one can search iteratively for a control approach that meets such goals at lower costs than the other candidate approaches.

The following key intermediary steps and information is necessary to carry out the cost/benefit analysis:

Identify Implementable Control Options: strategies proposed by the government agencies involved and other proposals could be submitted to a public attitude survey to screen out politically unacceptable options.

- Policy Cost Options includes estimates of direct production costs of each technological alternative, and, whenever possible, evaluation of cross-sectoral effects;

- Emission Inventories should be carried out based on the available information of source points, and ambient air quality levels;

- Ambient Concentrations should be evaluated for each control option based on dispersion models and monitors to be set up where necessary.

- Human Exposure: Indoor-outdoor concentration studies should be mounted to enable the epidemiologists to draw conclusions relative to the health hazards of that portion of air pollution in the field of public concern and responsibility; and o <u>Health Effects:</u> Epidemiological studies to be mounted if additional information is needed as to the extent and seriousness of the health hazards the pollutants are causing for the population.

<u>Valuation of Health Effects</u> is three-fold. First, a series of questions should be tied to the epidemiological surveys to improve the task of monetizing health effects. Examples of this piggybacking include:

- defining questions about the presence or absence of health end-points that can be monetized. These include symptom-days (in "normal" people and those with chronic disease), work-loss and bed-disability days, minor restricted activity days, asthma attack days.

- defining questions to elicit information on potential personal explanatory variables (e.g., family and individual income, work status, smoking behavior, baseline health, whether the individual receives paid sick leave, time spent indoors, presence of chronic diseases, etc.) and the appropriate form of the air pollution data (e.g., averaging times, treatment of indoor air pollution issues).

- defining questions to elicit information on medical services used by the respondent over some period of time (doctor visits, hospital stay, etc) related to respiratory distress, whether respondent has medical insurance, cost of medical services, wage rate, hours worked per week, per year, employment history (whether person stopped working, changed jobs, or is less productive because of chronic illness), avoidance behavior (what kinds of actions have been taken to avoid pollution exposure, frequency of actions, costs, degree of success).

- eliciting hospital cost data and service utilization rates by disease, by episode (from hospital study)

Second, independently from the epidemiological surveys, additional data should be collected and analyzed on medical costs and wage rates (for valuing lost work days).

Third, the existing literature on values for other types of health end-points plus data available from the target countries should be used to estimate additional benefits .

A measure of the magnitude of the externalized cost of pollution is produced based on the results of the health studies. The internalized pollution costs can be related through the evaluation of potential damage to health to the social cost of pollution. The decision on who should bear the social cost will be reflected through the strategy adopted to implement the pollution controls.

Understanding the role played by macroeconomic factors in issues of environmental improvement is the crucial element of the successful implementation of any air pollution control strategy. As it currently stands, air pollution problems are affected by policies that institutionalize inefficiency and waste, as well as those that protect or subsidize certain industries or segments of society at the expense of the general public. These policies range from controls over a country's financial system, income and tax policies, and the pattern of international trade to restrictions on the proliferation and free functioning of markets in particular goods and services, particularly high polluting goods, such as those trading in energy markets. They also include administrative policies and laws that create bureaucracies to plan and enforce pollution control and energy development.

Successful air pollution control strategies entail first the removal of existing incentives to pollute, and, second, the setting of a regulatory framework and economic measures that internalize the social costs of pollution into the relevant production functions of the polluting sectors in the economy.

Strong public information campaigns are needed to inform the population of the health hazards associated with behavior patterns for which they bear direct responsibility as for instance cooking with coal and smoking, major indoors air pollutants, and uneconomical consumption of energy and transport, major causes of outdoor air pollution.

RELATIONSHIPS BETWEEN CONTROL STRATEGIES AND HEALTH EFFECTS

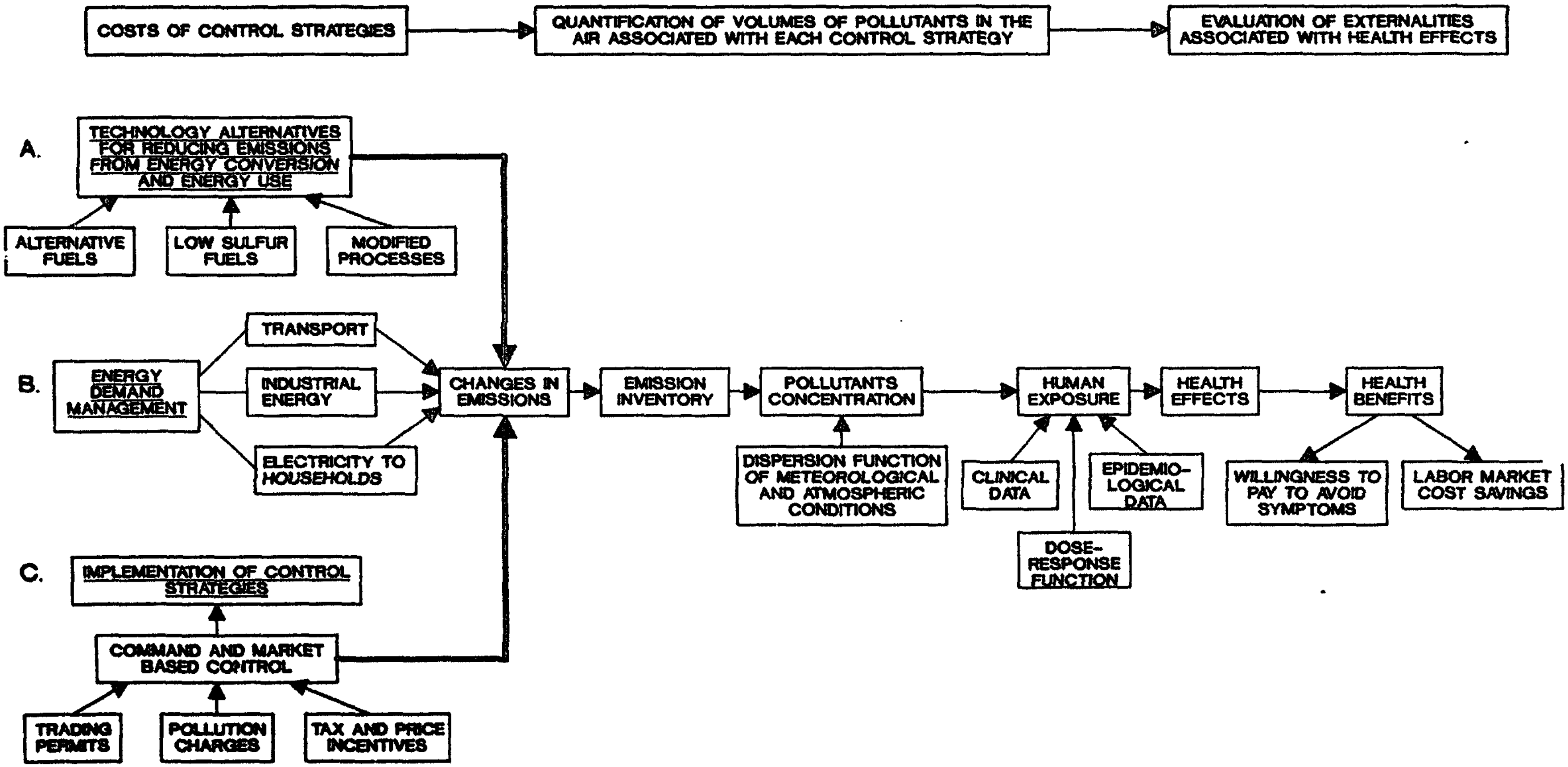

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Figure 2

OVERVIEW COST-BENEFIT MODEL OF AIR POLLUTION CONTROL

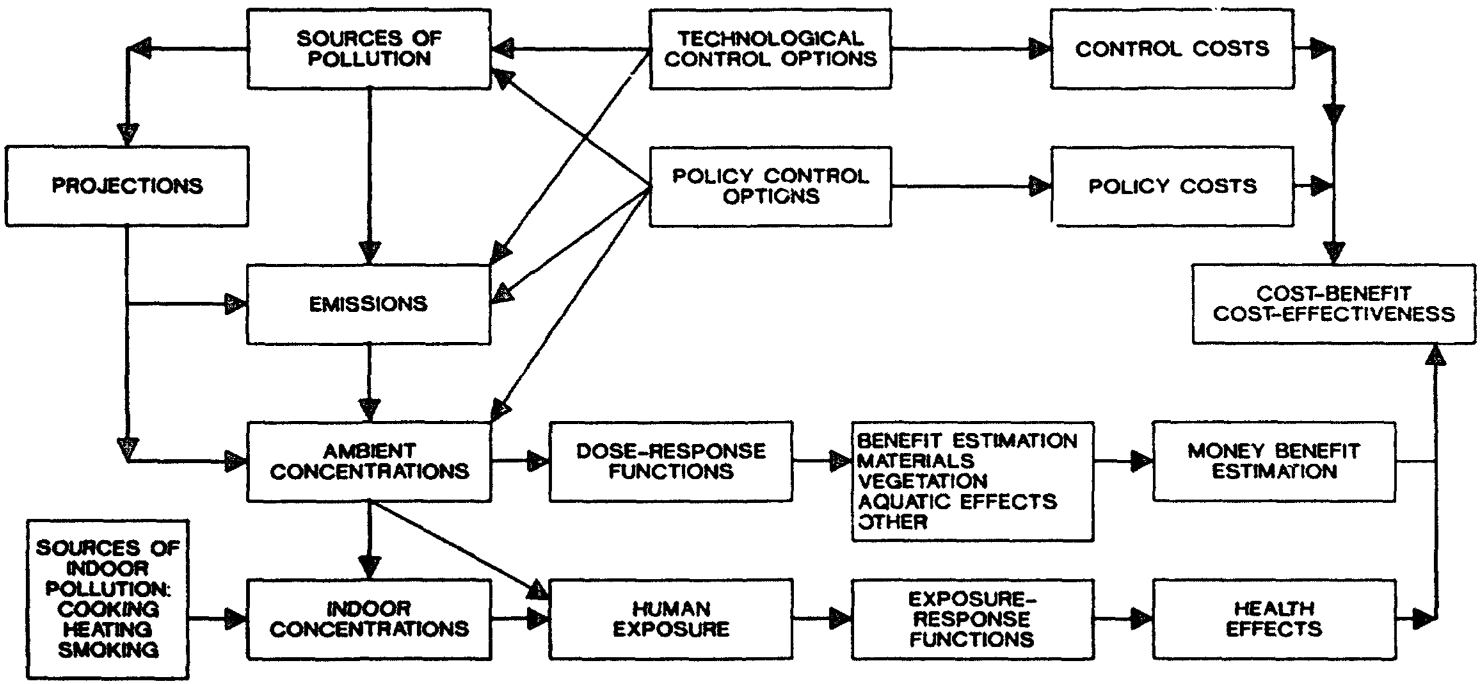

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Figure 3

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