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TRANSPORT AND ENVIRONMENT

by

Ibrahim Abdel Gelil and Zeinab Farghaly

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Transport and Environment

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Abstract

Efficient transport systems are essential for the functioning of modern societies, and welfare of people. The progress in mobility however has not occurred without negative effects on man and environment. Passenger and goods transport are contributing increasingly to a number of environmental problems at the local, regional and global level.

Due to escalating demand on transport, and continuing growth on number of vehicles especially in developing countries, the environmental impacts of the transport activities are increasing more than any other sector of the economy. Road transport contributing more than 80% of the total emissions of carbon dioxide in OECD countries.

The transport sector in Egypt is the third largest energy consuming one. Due to enforcement of air quality standards stipulated in law 4 for 1994, it has been recognized that a national program of vehicle emission control should be an essential component of an integrated national air quality management program.

This paper discusses the environmental as well as health impacts of the road transport sector, and how does promoting cleaner energy technologies and switching to cleaner alternative fuels could mitigate those adverse impacts.

The paper highlights Cairo air quality situation and Egypt's program to curb vehicles emissions.

1. Introduction

Efficient transport systems are essential for the functioning of modern societies. Mobility, and in particular, access to people, goods and services are essential for the welfare of people. The tremendous progress in mobility, however, has not occurred without negative effects on man and the environment. Numerous international studies on the state of the environment concluded that both passenger and goods transport are contributing increasingly to a number of environmental problems with long term and wide ranging impacts at the local, regional and global level. Major environmental issues concern noise, habitat-disrupting land use, air pollutant emissions and the increasing use of fossil fuels by motor vehicles as well as growing environmental impacts from global air traffic. Furthermore, the environmental effects caused by the transport sector are increasing more than any other sector of the economy due to the very strong links with GDP and the high growth rates of transport activity.

While all sectors of the economy together contribute to environmental pressures, there are considerable differences among the various transport modes. For instance, transport's share of polluting emissions vary from 25% for carbon dioxide to 90% for carbon monoxide with road transport contributing more than 80% of the total emissions in OECD countries. Transport's unaccounted - so-called external or social- costs due to health and environmental effects from noise, air pollution, congestion and time losses have been estimated between 4% to 8% of GDP of OECD countries. Road transport and aviation are primarily responsible for these costs, while rail traffic contributes less than one per cent of the social cost burden.

The transport sector in Egypt is considered as the third largest energy consuming one, its share of total energy consumption is 31.3% in 99/2000. With Rising environmental awareness on the national and international levels, and the enforcement of air quality standards stipulated in law 4 for 1994 and its executive regulations, it has been recognized that a national program of vehicle emission control should be an essential component of an integrated national air quality management program.

This paper discusses the environmental as well as health impacts of the road transport sector and how does promoting cleaner energy technologies and switching to cleaner alternative fuels could mitigate these adverse impacts. It also shed lights on Cairo air quality situation, and Egypt's program to curb vehicle emissions.

2. Transport sector and the economy

Transport is considered as one of the important sectors of the Egyptian economy. In addition to its vital role in the daily life of citizens, it contributed 9.6 % of GDP in 1999/2000.

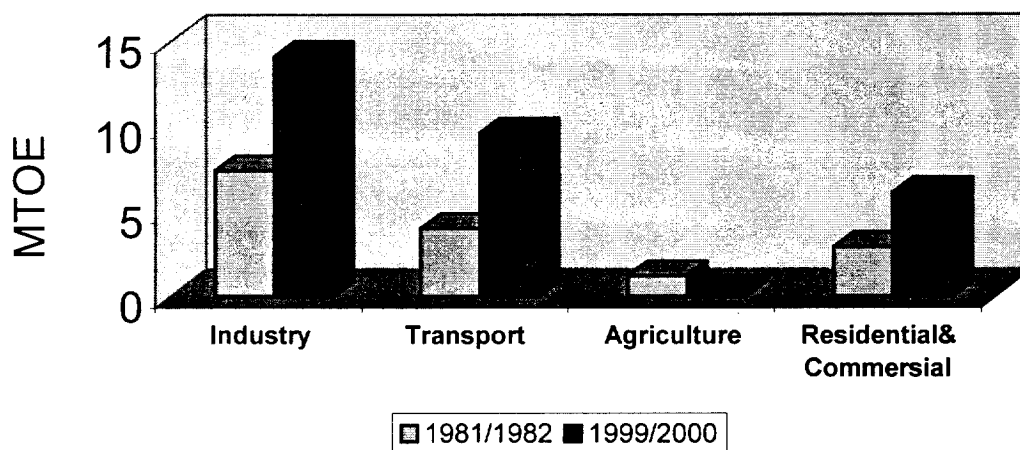
The government of Egypt started to implement several national strategies in order to secure the depletable oil resources, to improve air quality, and to mitigate some of the energy-environment related problems. Policies and measures to achieve these objectives include energy efficiency improvement; maximize natural gas use, energy prices reform, promotion of cleaner technologies and encouraging use of public transport.

3. Energy consumption of the transport sector

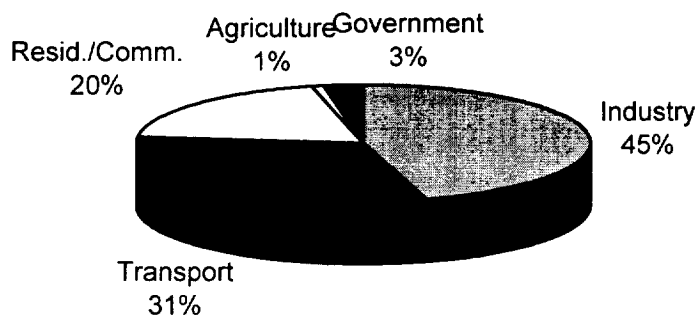
The transport sector in Egypt is one of the largest energy consuming ones. Its share of total energy consumption was about 9.6 million tons of oil equivalent in 1999/2000 representing nearly 31.3% of national total energy consumption compared to about 26% in 1981/82 (Fig. 1 & 2) .

*Organization for Energy Planning (1999/2000), Annual Statistics Report on Energy in Egypt.

**Fig. (1): Final Energy Consumption By Sector (MTOE)
(1981/82 - 1999/2000)**



**Fig. (2): Final energy consumption by sector
(1999/2000)**



4. Environmental impacts of the transport sector

Motor vehicle is generally recognized as the source of more air pollution than any other single human activity. In urban areas, where more than 50 per cent of the population of developing countries live, levels of motor-vehicle-related pollutants frequently exceed internationally agreed upon air quality guidelines. High levels of air pollution, apart from generally lowering the quality of life in cities, are also directly responsible for a large number of adverse health effects, ranging in seriousness from respiratory problems to carcinogenesis. A great deal of attention has been devoted to health effects of transport-related air pollution, and more research is needed to improve and consolidate knowledge of health environmental impacts and risks specially in developing countries. Motor vehicle emissions are complex and include hundreds of compounds that are released into the atmosphere as gases, aerosols and particulates. Many of these compounds are transformed in the atmosphere, producing secondary pollutants such as tropospheric ozone, acid aerosols and carcinogenic hydrocarbons, that are sometimes more harmful than their directly-emitted precursors. Major air pollutants emitted by motor vehicles include carbon dioxide (CO_2), carbon monoxide (CO), particulate matter (PM), nitrogen oxides (NO_x), sulfur dioxide (SO_2) and volatile organic compounds (VOC). Highly reactive VOC species in vehicle emissions are, along with NO_x emissions, the major motor-vehicle related precursors of tropospheric ozone (O_3). Motor vehicles are also a major source of a number of toxic and carcinogenic air pollutants, including VOC species (e.g. benzene, 1,3-butadiene, formaldehyde, acetaldehyde and polynuclear aromatic hydrocarbons), lead, fine particulate matter, etc. Emissions of these substances are largely related to fuel composition or fuel additives, as well as engine technology, and are often results of incomplete combustion. An important fraction of overall motor-vehicle related VOC emissions is contributed through evaporative losses during fuel distribution, storage, transfer and vehicle refueling, as well as from losses during vehicle use.

Carbon dioxide (CO_2), a radiatively active gas in the atmosphere, is of global importance due to its implication on global climate change. The mechanism is that CO_2 acts as a greenhouse gas and thus contributes to an increase in the planet's surface temperature. Carbon dioxide is related to the metabolism of plants and animals, and is regularly recycled through the biosphere, atmosphere, and oceans in a complex system that appears set to maintain the surface temperature of the Earth at about $+15^\circ\text{C}$. Other radiatively active gases can be produced during combustion of fossil fuels, but the greatest potential impact is believed to arise from the atmospheric accumulation of carbon dioxide. Atmospheric levels of CO_2 have been increasing for more than a century, roughly in line with the increased fossil fuel use associated with industrialization and with the motorization of transport. The effects of continued climate change could include more variable and extreme weather, raised sea levels, expansion of deserts and widespread destruction of plants, animals, and ecosystems unable to adapt to changes in temperature and other aspects of climate. Among the different vehicles classes, automobiles are currently responsible for the greatest amount of polluting emissions, particularly CO , VOC and CO_2 . On the other hand, heavy-duty trucks and buses are responsible for half the world's emissions of motor-related NO_x in spite of a comparatively small share (around 5 per cent) of the vehicle population. They are also the source of a large share of fine particulate matter emitted by diesel engines. The high output of NO_x and PM reflects not only the high fuel consumption and large amount of travel logged by heavy duty-vehicles, but is also indicative of comparatively poor standards and emission controls on this vehicle class. Policies adopted by many developed countries in the 1970s and 1980s proved effective in reducing emissions of some conventional air pollutants. For example, mean values of CO have been

decreasing in most urban areas in OECD countries due to improvement in emission controls. After a period of steady increase during the 1980s, average concentrations of NO_x have levelled off in many developed countries. However, projections for the growth in motor vehicle traffic suggest that in the absence of new control measures, emissions of CO, hydrocarbons and NO_x will rise again. And despite progress to date, pollution episodes due to motor vehicle emissions (e.g. smog) continue to occur frequently throughout the world and are a subject of growing public concern. Moreover, smog and the ingredients of acid rain spread from urban areas, causing damage to surrounding regions. In recent years, concern about the nature and scale of the climate change problem has led to numerous studies on the impact of the transport sector. CO₂ emissions from transport are directly proportional to gasoline and diesel fuel consumption. During a period when other sectors of energy consumption have begun to rely to a greater degree on other fuels, oil consumption by transport has been rising continuously. In OECD countries, transport accounts for more than 60 per cent of total oil consumption and about 20 per cent of total fossil fuel use. It is thus a major source of CO₂. Road transport generates other greenhouse gases, such as the CFCs (which are also ozone depleting) used in automobile air conditioning systems.

According to the third assessment report of the Intergovernmental Panel on Climate Change (IPCC), transport produces roughly 20% of global carbon emissions.

Noise is generally perceived by urban residents as the first and foremost as problem associated with road traffic. However, the effects of transport noise are not yet well understood, nor are there fully satisfactory measurements of noise and the nuisance it causes. In addition to being unpleasant, noise contributes to such health problems as stress disturbances, cardio-vascular disease, and hearing loss. People feel more directly affected by noise than by any other form of pollution. However, measuring the magnitude of noise pollution is rather complex.

As one of the major energy consuming sectors in Egypt, transport sector is considered as significant source of polluting emissions that includes lead, particulate, sulfur oxides and Greenhouse gases namely Carbon dioxide, Nitrous Oxide, and methane.

A new source attribution study undertaken in Cairo revealed that transport contributes about 22% of the total PM₁₀ concentrations.

5. Air quality in Cairo

Cairo is one of the world's megacities that experiences relatively high levels of many airborne pollutants, including lead, and particulate matter. Nearly 20% of Egypt's population live in Cairo as the city offers the greatest national culture, economic and political attractions. Cairo has experienced a rapid rate of economic and social development accompanied by poorly planned urbanization over the last few decades. The industrial development which doesn't consider environmental impact, combined with rapid population and economic growth, has led to an increase in the pollutants released into Cairo's air, water, and soil. The high pollution levels have raised major concerns for public health. Particulate matter and lead are two of the major atmospheric pollutants in Cairo that are reported to produce adverse health effects. Previous Studies that investigated the environmental health risks to Cairo residents invariably concluded that lead was one of the area's major hazards. An important step in reducing health risks due to lead exposure was taken when a lead additive was removed from gasoline sold in the Greater Cairo Area. It is

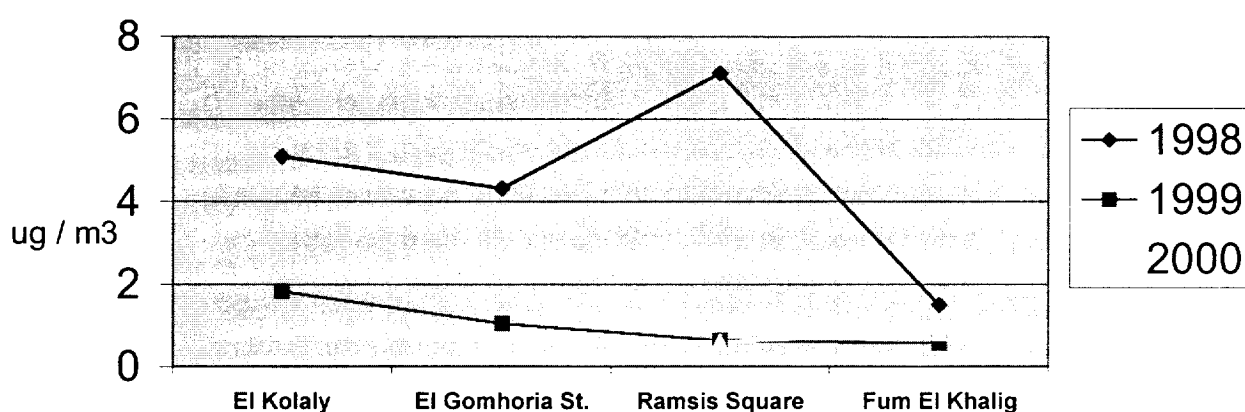
estimated that removal of the lead additive from gasoline probably reduced by more than one-half the quantity of lead emitted into Cairo's air. The action also reduced the general public exposure to lead from vehicular sources. However, high airborne lead levels still persist in areas where lead-emitting industries, specifically secondary lead smelters, are located, and the exposure to residents of these areas remains a significant threat to human health.

In a recent study, ambient airborne lead levels as high as 9 ug/m^3 were measured in the industrialized area of Shoubra el-Kheima, north of Cairo. The maximum lead level measured at traffic sites during the same study, was 2 ug/m^3 . Both exceeded the World Health Organization (WHO) standard of 1 ug/m^3 . It is likely that removal of lead from gasoline sold in Cairo in January 1996 has reduced general ambient lead levels. However, there remain areas of very high lead levels in the vicinity of lead processing facilities, most of which are currently using outdated technology or are not equipped with pollution control systems. The human exposure problem is exacerbated by the fact that there are many lead-processing facilities and they are scattered throughout greater Cairo in the proximity of residential areas.

The Egyptian Environmental Affairs Agency (EEAA), supported by the USAID has installed an air quality monitoring network consists of 36 monitoring stations located throughout Cairo. Sites of the stations are designated according to the type of land use in the vicinity of the station. They represent mainly residential, industrial, commercial and heavily traffic districts of Cairo, in addition to few sites considered as background. Samples of Data collected from the 36 air monitoring sites during the period September-December 1998 showed that the highest lead levels were observed in the two heavily industrialized areas of Shopra el Kheima and Tebbin. These sites are downwind from secondary lead smelters.

Fig. (3) shows reduction of lead concentration in selected locations of Greater Cairo since 1988. On the other hand, previous studies conducted in Cairo showed also high levels of airborne particulate matter (PM).

**Fig. (3): Lead conc. in Greater Cairo
(1998 - 2000)**

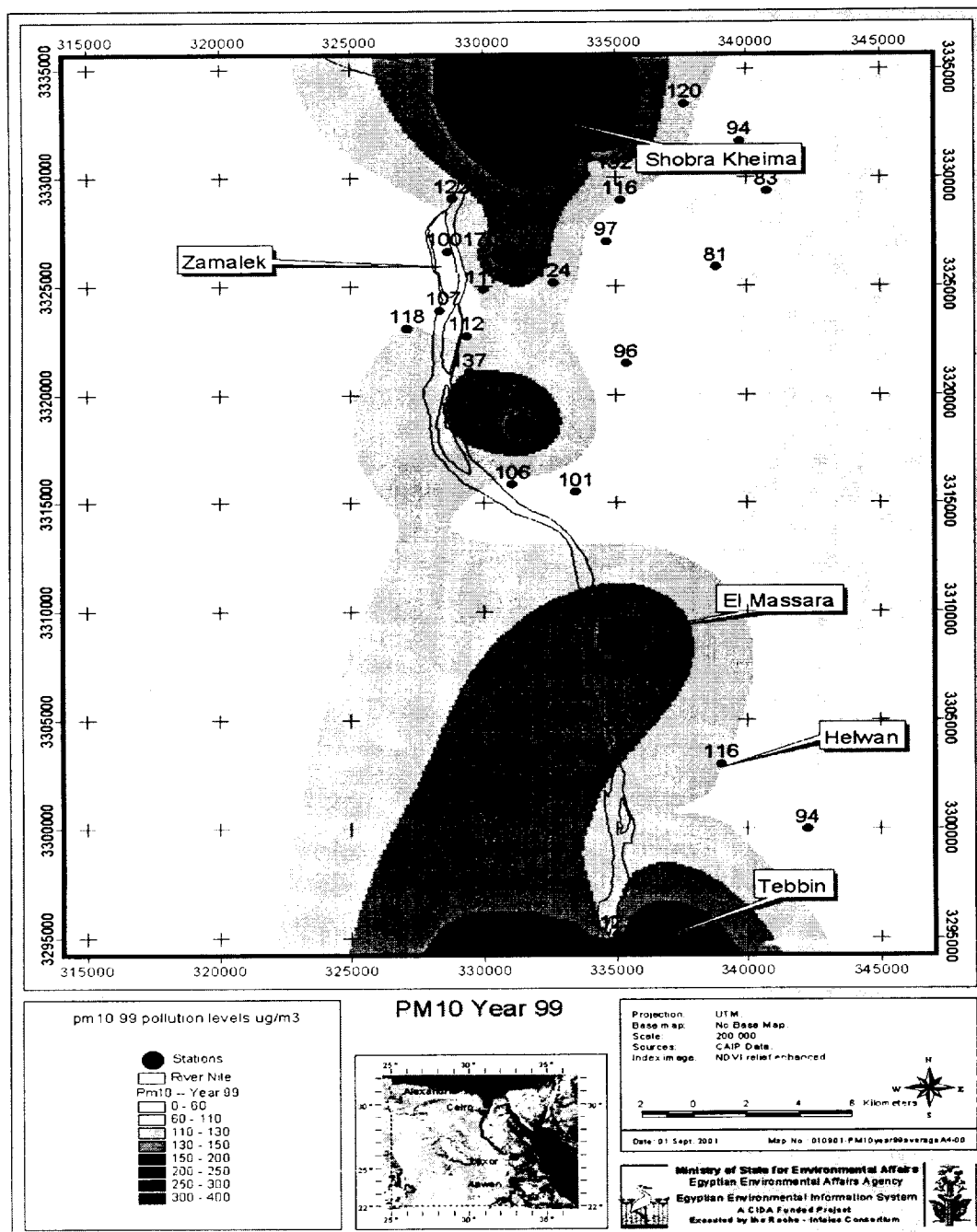


*Cairo Air Improvement Project, Egyptian Environmental Affairs Agency, (2000).

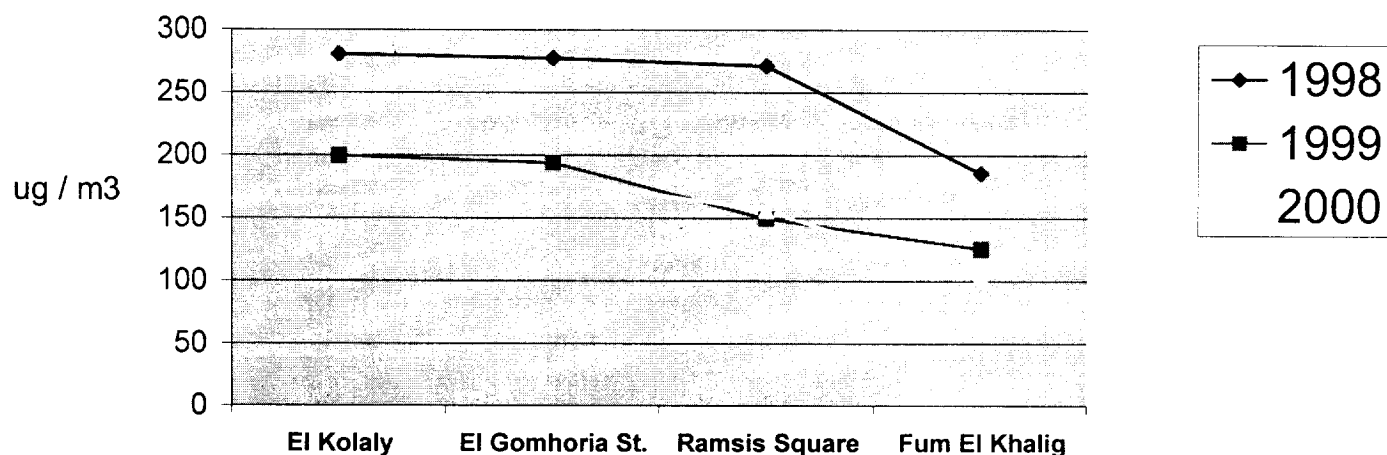
Data obtained during the same monitoring period of September-December 1998 indicated that particulate concentrations are generally high throughout the greater Cairo area. PM10 values obtained from all monitoring stations exceeded the Law 4 for 1994 limit of 70 $\mu\text{g}/\text{m}^3$ (24-hour average). The highest PM levels were found in industrial and heavily trafficked areas. However, it should be noted that PM levels that observed at some areas considered as background ones were more than twice the law limit. This indicates that compliance with the current law limit of 70 $\mu\text{g}/\text{m}^3$ may be impractical.

Fig. (4) Shows spatial distribution of PM10 in Grater Cairo, and Fig .(5) reveals the gradual reduction in PM10 conc. in Greater Cairo since 1998.

Fig. (4) : Spatial distribution of PM10 conc. in Grater Cairo (2000)



**Fig. (5): PM10 Conc. in Greater Cairo
(1998 - 2000)**

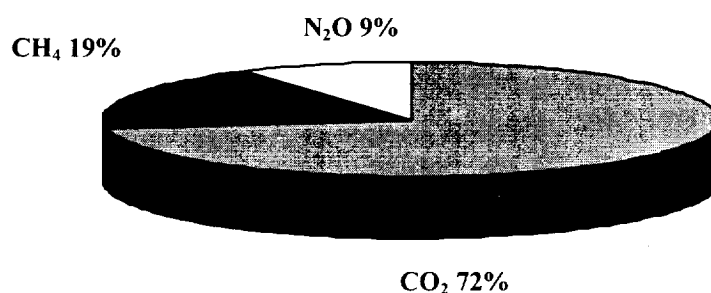


*Cairo Air Improvement Project, Egyptian Environmental Affairs Agency, (2000).

6. Greenhouse Gases (GHG) emissions of the transport sector

The total GHG emission of Egypt in 1990 is equal to 116,608 Gg of CO₂ equivalent using the 1995 Global Warming Potential (GWP) of the Intergovernmental Panel on Climate Change. Total GHG sinks in the land use sector equals 9,900 Gg of CO₂ equivalent, which makes the net emissions equal to 106,708 Gg of CO₂ equivalent. Fig.(6) shows the percentage share of emissions of each of the main greenhouse gases in Egypt.

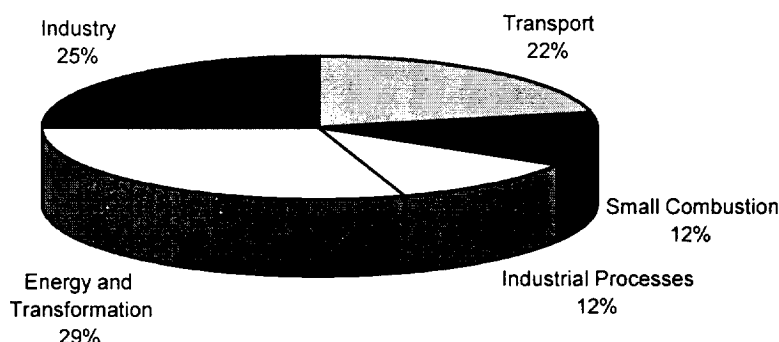
Fig. (6): Percentage share of major GHG (CO₂ equivalent)



*Egypt National Greenhouse Gases Inventory (1990/1991), (Nov. 1998).

The relative contributions of sources of **greenhouse** gases in the total emissions are presented in (Fig. 7) where it is clear that the energy sector is the main source of GHG emissions due to the fact that Egypt is 92% dependent on fossil fuels (oil and natural gas). In addition transport activities contributed nearly 22% of CO₂ emissions in Egypt in 1999.

□
**Fig. (7): Carbon dioxide emissions from different sectors
(1990/1991)**



*Egypt National Greenhouse Gases Inventory (1990/1991), (Nov. 1998).

7. National program for vehicle emission control

Based on the results of a comparative risk analysis of environmental problems affecting Cairo that was undertaken in 1993, and to mitigate the adverse environmental and health impacts of the road transport sector, it has been recognized that a programme of vehicle emission control should be an integral part of a national programme of air quality management. The Egyptian Environmental Affairs Agency (EEAA) is currently implementing that programme to reduce vehicle emissions and improve ambient air quality in Cairo and other major urban centers. Certain considerations have been taken into account while designing such programme. These include, firstly participation by a large number of stakeholders such as the Ministry of Transport, Ministry of Interior, Ministry of Health and local authorities at the Governorates levels. Secondly, Integration of the programme into national development plans to achieve sustainable development, and lastly to consider the international initiatives to mitigate global climate change.

7.1 Cairo air improvement project (CAIP)

At the center of that national programme is Cairo Air Improvement Project (CAIP), a 60 million US\$ Initiative supported by USAID and implemented jointly by EEAA and the organization for Energy Planning (OEP). Its goal is to initiate and implement measures to reduce air pollutants that have the most serious impacts on human health in Greater Cairo, especially suspended particulates and lead. One of the important objectives of CAIP is to collect air quality monitoring data to document improvements that result from pollution abatement interventions implemented by EEAA, CAIP, and other organizations.

CAIP's interventions include **Vehicle Emission Testing (VET)**, which aims to reduce vehicular emissions of harmful air pollutants and improve fuel efficiency. The **Lead Abatement (LA)** component is providing technical support to upgrade and relocate lead smelters in Cairo. The other two interventions are development of a fleet of public transportation buses fueled by Compressed Natural Gas (CNG) and **Air Quality Monitoring (AQM)**, which has established a system for measuring fine particulate matter (PM) and airborne lead in the ambient air of Greater Cairo.

PM in the air exists as a distribution of particles ranging in size from tens of micrometers (mm) to sub-micrometer in diameter. Large particles (greater than 10mm in diameter) do not pose a severe health risk since they are not readily taken into the body. Particulate matter less than 10mm in diameter (PM10) is a more significant health hazard since the fine particles enter the human respiratory system during inhalation. However, a sub-fraction of the PM10 particulate matter—the particles less than 2.5mm in diameter (PM2.5)—are the most dangerous, since particles of this size are transported deep into the lungs. The CAIP air monitoring program is measuring PM10 and PM2.5 since these size ranges are the most significant in assessing human health effects.

The objective of the Cairo Air Improvement Project is to mitigate the public health impacts of air pollution in Cairo, particularly those related to suspended particulates and lead.

7.1.1. Air quality monitoring

CAIP is operating a network of 36 ambient air quality monitoring stations around greater Cairo. The system, implemented in cooperation with DANIDA, Cairo University, and the Egyptian Geological Survey and Mining Authority, is based on reliable data collection methods and procedures for the determination of ambient air levels of PM-2.5, PM-10 and airborne lead, and of lead emissions from industrial sources

In the first fifteen months of the project (October 1997 through December 1998), CAIP designed the network; specified, procured, and installed the sampling equipment; initiated sampling operations; contracted with an analytical laboratory to analyze samples; and instituted rigorous quality assurance procedures. The network is in phase of operation now as standard operating procedures are fine tuned and adjustments are made. Bimonthly reports are produced on the particulates and lead concentrations in the 36 locations of greater Cairo. Currently, an assessment of upgrading the network and integrating it into the national air quality monitoring network is underway.

7.1.2. Vehicle emissions testing program

Motor vehicle emissions have been shown to be a major source of health problems in the greater Cairo area. A pilot vehicle emission testing (VET) program demonstrated that following a low-cost tune-up, significant reductions in HC and CO emissions (35 and 62 percent, respectively) were realized and fuel efficiency gains averaging nearly 15 percent were observed. With most vehicles in Cairo carbureted, and approximately 65 percent of the fleet at least 10 years old, a program leading to low-cost tune-ups can lead to a marked improvement in air quality and fuel economy.

CAIP is designing and supporting implementation of a network of stations throughout the greater Cairo area for testing vehicle tailpipe emissions.

This complex effort involves **developing the network design**, specifying and procuring testing equipment, designing and building several model test centers and a technical center, building local tune-up capacity, and working with the Egyptian Environmental Affairs Agency and the Traffic Authorities to assure sustainable oversight and management of the program.

7.1.3. Natural gas for transport

CNG activities under CAIP are intended to reduce emissions of particulate matter, NO_x, and SO_x, in Greater Cairo by expanding CNG as a vehicle fuel. Work is focusing on public bus and minibus fleets by procuring and developing institutional readiness for a CNG vehicle demonstration fleet within two public transit agencies of Greater Cairo, CTA(Cairo Transportation Authority) and GCBC(Greater Cairo Bus Company). In 2000, CAIP furnished Cairo's municipal bus companies with fifty CNG-powered rolling bus chassis, and the Government of Egypt is contributing the bus bodies. The end of 2000 will place all fifty buses into commercial service in Greater Cairo. CAIP has also helped equip the CNG bus maintenance garages required for these fleets, and worked collaboratively with the Government of Egypt to introduce CNG-related safety standards for fuel tanks, fueling stations, and fuel systems.

In addition to CAIP, EEAA is implementing a set of other initiatives aiming at reducing vehicles emissions to improve air quality in Cairo and other major cities. These are:

7.2. Fuel switching

Current Egyptian energy policy calls for shifting the demand from liquid fuel oil to natural gas. This is due to the abundance in natural gas supply estimated to be over 50 trillion cubic feet (CF), and with the identified 3D seismic potential, can reach 120 trillion CF. Fuel switching is currently being applied to the electricity generation, industry, and residential sectors. Traffic growth is projected to continue to increase significantly world-wide. Road transport typically contributes the major percentage of the total emissions of several key pollutants due to large increase in the number of vehicles. This results in deteriorating air quality in urban areas especially in megacities. There has been a rapid growth in the use of gas as a vehicle fuel with estimated natural gas vehicle (NGV) number exceeding 1 million world wide. The leading countries include New Zealand, Italy, Canada and Egypt. Most NGVs can run on either gas or gasoline but the more wide spread introduction of dedicated vehicles which run solely on natural gas would make an even greater contribution to reducing future emissions from the transport sector of major pollutants such as CO₂, CO, Ox, non-methane hydrocarbons, and SO_x. In Egypt, two companies have been established to convert vehicles to use compressed natural gas, and to construct CNG fueling stations. To date, 27 fueling stations have been constructed in different locations, more stations are under construction. In about five years since the start of this programme, about 35000 vehicles have been converted. Currently, Egypt ranks number 8 out of 43 countries involved with CNG operations.

7.3. Energy pricing reform

Domestic energy prices have been characterized by a great deal of rigidity for a long period of time. The under pricing of energy products has promoted unwise consumer behaviors, and non-optimal investment strategies. For decades, the Egyptian economy has suffered from severely subsidized energy prices used to be as low as 5 % of their opportunity costs. Furthermore, the artificially low domestic prices of energy have also impaired the economic viability of most of the efficiency projects. Within the ongoing economic reform program, the government has decided to escalate the energy prices gradually to their economic levels. It should be noted that, though the market prices of petroleum products, natural gas and electricity have increased since 1985, their current real prices are still under the economic levels. However, the expected effect of the pricing policy on slowing down the growth in demand has been evident in the last few years.

Development of fuel prices of the transport sector during the period (1980/81 – 1996/97) is shown in table (1). It is clear from that prices of gasoline have been decreased in real terms since 1980. Furthermore, the prices of diesel and gas oil have increased only by 1.5% and 1.8% during the same period respectively.

Table (2) indicates that current fuel prices in Egypt still far below their levels in many developed countries. Gasoline is sold in Egypt with prices as low as 25% of that sold in Italy. Diesel fuel prices in Egypt is only 11% of that sold in the U.K.

Table (1) Fuels prices (1980/81 – 1996/97)

Unit: L.E/Ton

Year	Gasoline		Gasoline		Gas Oil		Diesel	
	80		90					
	Current	Fixed	Current	Fixed	Current	Fixed	Current	Fixed
80/81	182	182			36	36	30	30
81/82	182	165			36	33	30	28
82/83	210	166			36	28	30	24
83/84	210	143			36	24	30	21
84/85	210	122			36	21	30	18
85/86	280	145	280	145	36	19	30	16
86/87	350	146	420	176	36	15	30	13
87/88	350	122	420	147	60	21	53	18
88/89	490	146	560	166	60	18	53	16
89/90	490	120	560	137	84	21	76	19
90/91	770	162	840	176	120	25	105	22
91/92	980	172	1120	196	240	42	211	37
92/93	980	151	1120	173	360	56	316	49
93/94	1260	173	1400	193	480	66	421	58
94/95	1260	164	1400	182	480	62	421	55
95/96	1260	129	1400	143	480	49	421	43
96/97	1260	120	1400	134	480	46	421	40
GR%	12.9%	-2.6%	10.6%	-0.50%	17.6%	1.5%	17.9%	1.8%
80/81 - 96/97								

Fixed prices are 80/81 prices

* Korkor, H (1999), Energy Planning of the transport sector in Egypt in the context of Environmental concerns.

Table(2) Fuel prices (US cents per liter)
(1993 – 1998)

	Super Gasoline			Diesel		
Country	1993	1995	1998	1993	1995	1998
Australia			46			45
Canada	47	45	41	39	36	39
Cyprus			78			25
Egypt	30	29	29	9	12	12
Finland		120	117		85	79
France		117	111		78	77
Germany		112	96		77	69
Italy		118	119		86	93
Japan		125	102		75	69
Sweden		117	109		101	84
Switzerland		102	86		101	91
United Kingdom		92	111		85	111
United States			35			31

*World Bank Statistics, (2000).

7.4 Vehicle engine tuning

There are many authorities that are responsible for operating huge numbers of vehicles such as, Greater Cairo Bus Company, and Cairo Transport Authority. These entities could support the national environmental programs through implementation of special programs to control emissions through maintenance and tune-ups. One example of these programs is vehicles engine tuning program that aims to reduce emissions of public transport buses by about 35%. The main tasks for the program include testing buses engines efficiency, identify engine defects leading to increasing emissions and tuning up.

The first phase of the program includes purchasing of equipments for different garages and training of the staff on testing and tuning processes. The second phase covers the testing, tuning which followed by monitoring and evaluation of results. This program is currently underway, and still in its early stages.

7.5 Conversion of two stroke engine motorcycles to four stroke

As the motorcycles is one of the means of transportation in Egypt specially for poor people, and due to the high emissions of hydrocarbons and particulates resulted from operating these motorcycles. An integrated three years program aims to reduce emission from motorcycles has been developed. This program has three main tasks, first to restrict usage of the two stroke engines motorcycles in urban areas, second to convert the two stroke engines motorcycles to four stroke engines or to convert it to compressed natural gas, finally the third task is to stop importation and local manufacturing of two stroke engine motorcycles within three years.

The ministry of industry has issued a decree to stop licensing any new factories or expand any existing production lines of the two stroke engine motorcycles starting July 2001.

7.6. Demonstration of new technologies

Significant energy efficiency technologies are now available for purchase in at least some OECD countries. In 1997, a commercial hybrid electric vehicle was first introduced in Japan. In 1998, a practical zero-emission gasoline-powered passenger car was developed, and demonstrated. Egypt has been not far from these developments at the international level. With active partnerships with the Global Environment Facilities (GEF), and the Canadian government, Egypt is currently implementing three projects to demonstrate Electric Vehicles (EV), fuel cell powered buses, and retrofitting of two stroke engines motorcycles.

7.6.1. Hybrid-electric bus technology in Egypt

The overall objective of this project is to introduce to Egypt a viable Hybrid-electric bus that will have significant economic and environmental benefits and sustainability in various segments of the country. The project will be applied to high priority historical sites starting with the Giza plateau where the ancient pyramids are located. Contributing to a long term cost reduction will enable the technology to reach commercially viable levels in a much shorter time. This demonstration will have a marked impact on global abatement of greenhouse gases, reducing the pollution in Egypt and meeting some of the objectives of Egypt's national program, in addition to serving as example to other megacities worldwide.

The project will cover testing of the electric buses in various routes, training on maintenance and operation of this new technology and economic, environmental and social studies. This project is currently in its early stage of implementation.

7.6.2. Fuel cell bus demonstration project

The unique advantage of hydrogen as a fuel is that it is one of the most abundant elements in the universe. The vast majority of hydrogen needed to power tomorrow's world would be manufactured as a byproduct of renewable or environmentally acceptable technologies. Until renewable technologies are proven to be reliable and economical, most of the hydrogen manufactured will continue to be a byproduct of fossil fuels such as natural gas and the water electrolysis.

In Egypt, there is a good potential for hydrogen production. Reformers are currently in use in fertilizer and petrochemical facilities - such as Abu Qir Fertilizer Factory, and different oil refineries - to produce hydrogen. Electrolysis systems are also being used in Egypt in some facilities such as Kima fertilizer company to produce hydrogen through hydropower electrolysis of water. On the other hand a large number of Egyptian Institutions have undertaken research on fuel cell technology concerning its different aspects. Egypt is, therefore, very well positioned to be able to absorb fuel cell technology, and consequently to use hydrogen fuel on a large scale as the most favorable fuel for fuel cell operation. Accordingly, through the GEF, the UNDP is currently supporting fuel cell bus demonstration projects in Cairo to reduce GHG emissions and other pollutants. The demonstration project in Cairo features eight fuel cell buses with associated hydrogen production and supply

facilities. The program will run for five years, with three years devoted to driving, monitoring and testing performance. The project is expected to start in 2001 with a focus on technology transfer, Egypt hopes to expand the success of this demonstration to contribute to the development of this technology at the international level.

7.6.3. Retrofitting of two stroke engines motorcycles

This is a demonstration project of a Canadian technology developed to reduce the emissions of GHG by converting two-stroke engines used in motorcycles to compressed natural gas (CNG). The project is implemented in three phases: identification of capabilities and barriers, demonstration of the technology, and a hand-over and transition to the local market. After converting and testing one motorcycle in Canada the second phase of converting a sample of 20 motorcycle in the local conditions will start soon. This project is a good example of public private partnership at both the Canadian and Egyptian sides. The project is complementing the national program to phase-out two stroke engines within three years.

Conclusions

Efficient transport systems are essential for the functioning of modern societies. Due to escalating demand on transport, and continuing growth on the number of vehicles especially in developing countries, the environmental impacts of the transport activities are increasing more than any other sector of the economy. Road transport contributing more than 80% of the total emissions of carbon dioxide in OECD countries. A source attributed study undertaken recently in Cairo revealed that transport contributes about 22% of the total PM10 concentrations. Inventory of Greenhouse Gases (GHG) emissions in Egypt in 1990 showed that transport sector is also emitting 22% of Egypt's total CO₂ emissions.

A program of vehicle emission control, which is currently underway, is an integral part of Egypt's national air quality management strategy. A number of initiatives are being implemented to curb emissions of the existing fleet of vehicles. These include vehicle emission testing program, switching to compressed natural gas (CNG) as a transport fuel, reforming of energy prices, and demonstration of energy efficiency technologies. With support from the Global Environment Facility (GEF), and bilateral international cooperation agreement, Egypt is implementing a number of demonstration projects to test environmental and economical viability of fuel cell technology, electric vehicle technology and retrofitting of the two stroke motorcycle engines to use CNG.

As a result of those activities, air quality monitoring data in Cairo and other major cities indicated a remarkable decrease of ambient concentrations of lead, PM10, SO₂, CO and NO_x.

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