TECHNICAL EVALUATION OF TRANSPORT-RELATED GREENHOUSE GAS ABATEMENT TECHNIQUES

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ABSTRACT

The world community has many needs for reliable measures to reduce the greenhouse gas emissions, as it discusses climate change. To evaluate the effectiveness of possible abatement measures, the paper firstly presents a "minimum data" emission estimation method. This method was based on the assumption that the greenhouse gas emissions depend on fuel consumption, fuel quality, and transport activities. This assumption may be probable as a starting point for countries which have limited experience with emission estimations. Then, a catalogue of abatement measures was prepared and an evaluation process was developed to investigate the effects of each individual measure and measure combinations. The paper demonstrates also an application to Egypt, as a case study. Three abatement scenarios were proposed and compared with a reference scenario which was established on the basis of "business as usual" travel demand.

Keywords: Environment, Air pollution, Greenhouse gas, Transportation planning

1. INTRODUCTION

The transportation systems play a major role in the economic life of each country and in the daily lives of its citizens. The movement of people and goods increases significantly with the rapid economic growth in both developed and developing countries. The increase in mobility is generally considered to be a positive aspect. However, too much traffic on a given transportation infrastructure leads often to negative effects. These negative effects include congestions, accidents, noise, and pollution.

The transport sector is a major consumer of fossil fuels and therefore contributes a significant share of the emissions of "greenhouse gases" (GHG). The most prevalent GHG emitted from the mobile sources is the carbon dioxide (CO_2). Generally, GHG emissions have negative health effects and initiate environmental damages. The increase of emission concentration in the air can cause acid rain and global warming of the atmosphere.

Unfortunately, emission estimates, worldwide, are often unavailable or uncertain. The definitions, the methods, and the assumptions used for emission estimation are frequently different and consequently the resulting estimates will be varied and ambivalent [1].

Accurate emission estimates are urgently needed to assist countries by preparing their own GHG emission inventory [2], and by assessing emission differences among different control technologies and transport policies.

The primary objective of this paper is to identify an estimation method for GHG emissions from mobile sources, which should be established on a "minimum data set". Such method can provide direct guidance to countries preparing inventories of GHG emissions for the first time. The paper presents also an evaluation process which is developed to compare the relative contribution of the different transport systems, and to evaluate the effectiveness of several measures required for the reduction of GHG emissions.

2. ESTIMATION METHOD FOR TRANSPORT-RELATED GHG EMISSIONS

2.1 GHG Emissions from Mobile Sources

The emissions of greenhouse gases from the mobile sources include carbon dioxide (CO_2), nitrogen oxides (NO_x), nitrous oxide (N_2O), carbon monoxide (CO), methane (CH_4), and non-methane volatile organic compounds (NMVOCs). These Emissions can be estimated by the major transport activities; road, rail, water, and air. Several fuel types need to be considered; gasoline (benzin), gas oil (diesel), fuel oil (solar), and jet fuel. If these fuels (mostly composed of hydrocarbons) are completely combusted, the only products emitted would be CO_2 and water. However, under actual conditions, not all the fuel is combusted completely [3].

As one example of combustion-related emissions, the motors release large portions of NO_x and N_2O emissions. These emissions are closely related to air-fuel mixes and combustion temperatures.

The amount of CO emissions is a function of the efficiency of the post-combustion. CO emissions are highest when air-fuel mixtures are "rich", with less oxygen than required for complete combustion. This occurs especially in idle, low speed, and cold start conditions.

CH_4 emissions and NMVOCs from the motors are a function of the methane content of the fuel, the amount of hydrocarbons passing unburnt through the engine. The emissions of unburned HC, including CH_4, are lowest when the quantity of hydrogen, carbon, and oxygen are present in exactly the right combination for complete combustion. Thus, CH_4 and NMVOC emissions will be determined by the air-fuel ratio. They are generally highest in low speed and engine idle conditions.

2.2 GHG Emission Estimation

The estimation of mobile sources emissions is a very complex problem that requires consideration of many parameters such as: engine type, fuel quality, vehicle age, maintenance level, fuel consumed, and the operating characteristics.

The wide variety of parameters that can affect the GHG emission estimates makes it very difficult to generalize an emission inventory procedure. In fact, the complexity of this issue make it difficult even for countries with extensive experience to develop highly-precise emission inventories [4]. As such, it is appropriate to avoid excessive complexity with any starting emission estimation methodology.

A minimum emission estimation methodology will be suitable as a starting point, particularly for countries which have limited experience with estimation of emissions from mobile sources.

In order to develop a "minimum estimation" method for GHG emissions from mobile sources, the minimum data required are the fuel consumption of the individual transport modes, the average carbon content for each fuel type, and the transport activities. Thus, as a first approximation, GHG emissions should be adjusted in direct relationship to fuel economy. The basic approach for estimating the emissions is:

$$\text{Emissions} = \Sigma\ (EF_{a,b,c} \times \text{Activity}_{abc})$$

where,

EF	=	Emission factor (e.g. gram emission per vehicle-km)
Activity	=	total transport activity (e.g. vehicle-km)
a	=	transport mode (road, rail, water, air)
b	=	fuel type (gasoline, gas oil, fuel oil, jet oil)
c	=	vehicle type (car, taxi, bus, truck, train, etc.)

The fuel economy can be used to calculate the emission factor (EF) as follows:

$$EF = SEC \times ESER$$

where,

SEC	=	Specific energy consumption (e.g. MJ per vehicle-km) (MJ = mega joule = 10^6 joules)
ESER	=	Energy-specific emission rate (e.g. gram emission per MJ)

Other units may also be the basis for the calculations: Emission factor in gram emission per passenger-km (g/pkm) or per ton-km (g/tkm), and the transport activities in total passenger-km and in total ton-km.

The use of energy-specific rates (gram emission/MJ), instead of fuel-specific rates (gram emission/liter fuel), is always recommended to avoid the differences of carbon content anticipated in the fuel used in the various countries (i.e., fuel quality) [5].

It is important to remember that there is a substantial amount of uncertainty surrounding emission estimation. The calculations ignore several parameters, such as:

- The operating characteristics (e.g., percent of driving in cold start or in hot start, as well as average speed and ambient temperatures).
- The maintenance level (e.g., air-fuel ratio).

Some procedures should be developed to improve the data quality and to resolve uncertainties affecting emission estimates. This may involve the use of standard deviations, ranges of uncertainties, or some other means of indicating the reliability of the data. This issue must receive additional attention in any follow-up process.

2.3 The Emission Procedure

The following basic steps are required to estimate mobile source emissions:

(1) Determine the amount of fuel consumed by type for all transport modes using national data (gram or liter fuel/ veh.-km).

(2) Calculate the specific energy consumption for all transport modes by fuel type (e.g., MJ/veh.-km).

(3) For each fuel type, determine the energy-specific emission rates (e.g., gram emission/ MJ).

(4) Multiply the specific energy consumed by each transport mode by the energy-specific emission rate to determine the emission factor for all modes (e.g., gram emission/veh.-km).

(5) Determine the total distance traveled for each transport mode (e.g., Veh.-km).

(6) Multiply the emission factor for each transport mode by its total transport activity to compute the total emissions by mode.

(7) Emissions can then be summed across all fuel and transport mode categories to determine total emissions from mobile source-related activities.

Specific energy consumption and energy-specific emission rates should be country-specific whenever possible. If these specific data are available, they should be used, otherwise international data can be used as default assumptions. For the calculation of energy consumption, the most reliable source is probably the International Energy Agency (IEA), where statistics on transport activities are detailed by fuel type and transport mode [6]. These data are available for most mobile source energy consumption in the world with a great level of detail which can facilitate inventory calculations.

3. GHG ABATEMENT TECHNIQUES

As traffic continues to grow on a given transportation infrastructure, two basic strategies are needed: (a) changing the planning concepts to combat the large-scale environmental problems, and (b) introducing technical solutions to reduce transport-related energy consumption and environmental damages.

3.1 Changing the transportation planning concepts

The objective of changing the transportation planning concepts is not to improve the environmental performance of an existing transport system but to change the transport system itself with a view to the environmental constraints. Two planning concepts are recommended: (1) Reducing the transport demand, and (2) Modal shift from less to more environmentally friendly transport modes.

3.1.1 Reducing Travel Demand

For reducing travel demand, proposals should be made on the basis of an integrated land use/transportation planning. The need to co-ordinate land use and transport systems is especially acute in the main cities of most developing countries where almost uncontrolled population growth and motorization generate long trips and congested traffic.

In many cases, urban development have induced the spatial segregation of working, residential, shopping, service and recreational functions. In contrast, development patterns remain highly centralized in the city center which often contains most of the local administration offices, financial houses, and warehousing activities.

This development must be stopped. Reversing the spatial segregation of the urban functions will not be possible in the near future. Measures have to be taken to halt this trend and to facilitate the changes in the medium and long terms.

In addition, effective use of telecommunication systems may also represent reliable opportunities for reducing travel demands.

3.1.2 Modal Shift to environmentally more friendly Transport Modes

The financial charges imposed on travelling by car and shipping goods by trucks are simply too low to reflect the real social cost incurred (environmental damages).

The concept of road pricing in cities as a planning tool for modal shift from road to other transport systems attracts recently more and more attentions [7]. Singapore, Hong Kong, and Oslo are already following this path. Cars entering certain roads are charged with a road user fee, and these charges may be varied between peak and off-peak hours. The general philosophy of road pricing in cities is to penalize the use of car, if public transport systems are available. The income generated by the road user fees may be invested in improving public transport.

A more encompassing way of "setting prices right" lies in the taxation of road transport. Annual registration taxes have little effect on actual driving patterns as they are fixed costs to the motor vehicle owner [8]. The variation of registration fees according to the car's fuel consumption or the emission behavior may influence at least the distribution of a country's car fleet between more and less fuel consuming.

People have to be lured out of private car into railways and public transport modes. Criteria for the attraction of railway and public transport system are multiple. Certainly, their speed, comfort, reliability, schedule and network design are crucial factors. Permanent right-of-way for light railways, separate bus lanes, park-and-ride facilities, an extended night service and the improvement of the public transport image are also items in a whole catalogue of possible actions.

Additional measures which have other planning objectives, such as traffic calming, can support the emission abatement techniques. Traffic calming measures, for example, can reduce the convenience of private car use, make it less attractive, and may thus indirectly contribute to modal change.

For freight transport, service quality factors such as frequency, regularity, flexibility, safety, customer delivery conditions, and transport cost are the decision-making parameters of the transport user. A modal shift strategy for goods transport must be based on the complementarily between rail, waterways and the road.

The introduction of a sea-waterway or a sea-railway combined system is a far-reaching objective, not only for reducing the heavy traffic in overcrowded urban areas but also for minimizing the overall transport costs.

3.2 Technical Solutions

In the last few years, technical solutions, such as maintenance of vehicles to the manufacturer's specifications, catalytic converter, and improving the fuel efficiency, achieved a great success in reducing the amount of emissions emitted from mobile sources.

Today, some hopes are put in the introduction of alternative fuels (e.g., methanol, ethanol, natural gas and hydrogen) as well as in the electric vehicles. However, in calculating the overall effect of these options, certain trade-offs have to be taken into account. The pollution costs at the stage of producing the alternative fuel or electricity have to be considered [9].

In view of the fact that cars, buses and trucks will remain important pillars of the transport system, technical solutions are undoubtedly important element in a concept to make transportation more environmentally sustainable. Ultimately, a true "zero emission car" propelled by renewable energy is unlikely to be put on the road in the foreseeable future. While the industry is stepping up its efforts to develop new technical solutions, many technical problems still have to be overcome. Time would be needed for the conversion of car fleet to new technologies and for the creation of new fuel distribution systems.

3.3 Abatement measures Catalogue

Table (1) presents different measures that may be needed by preparing an abatement program for reducing the petroleum energy needed for the transport sector and consequently the GHG emissions. The table also shows the objectives of the individual measures.

4. EVALUATION PROCESS FOR GHG EMISSION ABATEMENT TECHNIQUES

Figure (1) shows the multi-stepped process proposed to evaluate abatement techniques. Based on the transport activities (in the base year) and the national fuel economy, the GHG emissions can be calculated. Then, different scenarios for reducing the GHG emissions (in the target year) are prepared and analyzed. Each Scenario may contain an abatement measure or a set of measures (i.e., combination of measures from the catalogue in Table 1). The scenarios should be compared with each other as well as with the so-called "reference scenario". The reference scenario is defined as the solution which is based on the authorized transportation master plan, if available, and/or "business as usual" travel behavior.

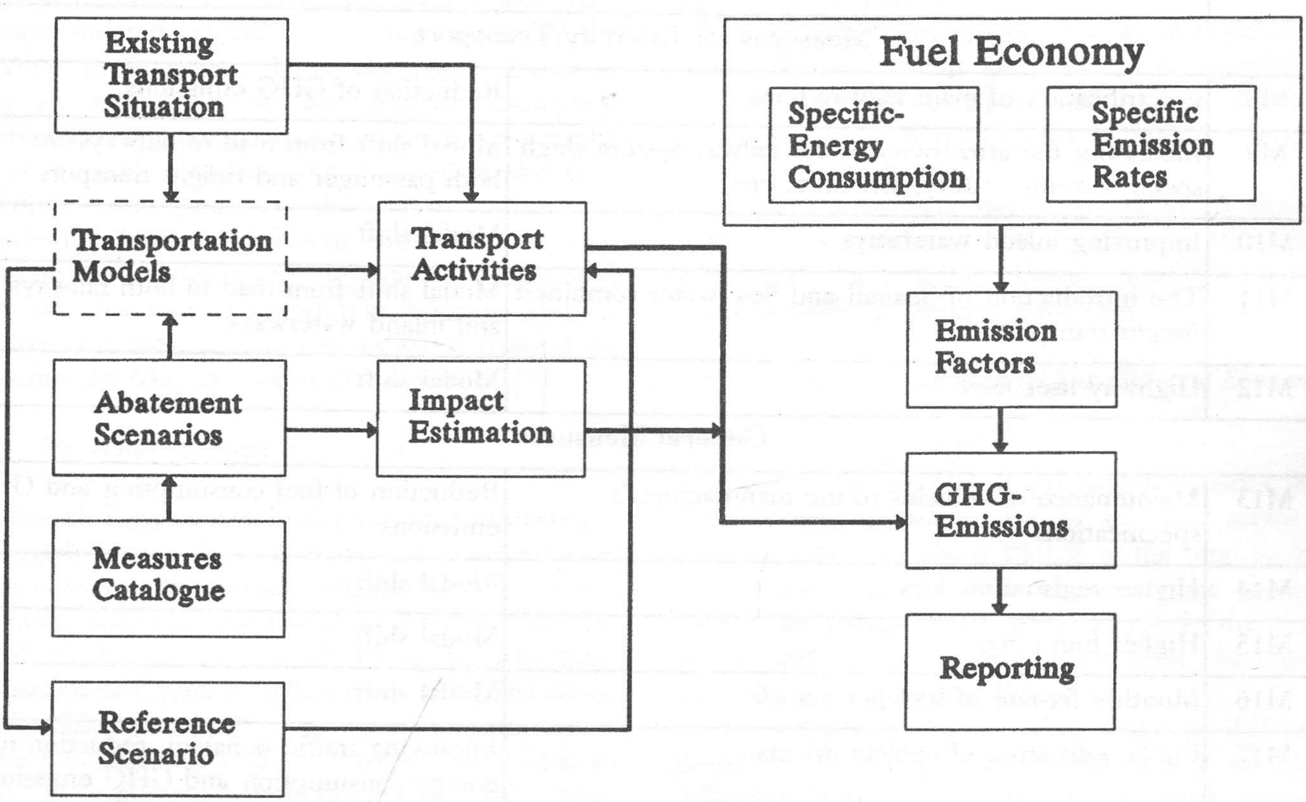

Figure 1. The Evaluation Process for GHG Emission Abatement Techniques

Table 1. Abatement measures for the Reduction of transport-related GHG Emissions

Measures		Objectives
Measures for Short distance Transport		
M1	Integrated land use/transportation planning	Reduction of travel demand
M2	Upgrading public transport systems	Modal shift
M3	Creation of Pedestrian facilities	Modal shift
M4	Environment-oriented improvement of road network and the introduction of automatic traffic Signalling	Reduction of traffic delays, as well as energy consumption and GHG emissions
M5	Road pricing / road licensing / parking restrictions / traffic calming	Reduction of car use in sensitive areas, modal shift
M6	Traffic priorities for bus and taxi	Modal shift
M7	The introduction of freight transport centers	Minimizing truck movements in urban areas, and reducing GHG emissions
Measures for Intercity Transport		
M8	Electrification of main railway lines	Reduction of GHG emissions
M9	Increasing the attractivity of the railway system (high speed, comfort, safety, schedule, etc.)	Modal shift from road to railways for both passenger and freight transport
M10	Improving inland waterways	Modal shift
M11	The introduction of Sea/rail and Sea /water combined freight transport	Modal shift from road to both railways and inland waterways
M12	Highway user fees	Modal shift
General Measures		
M13	Maintenance of vehicles to the manufacturer's specifications	Reduction of fuel consumption and GHG emissions
M14	Higher registration fees	Modal shift
M15	Higher fuel price	Modal shift
M16	Monthly fix-rate of fuel per vehicle	Modal shift
M17	Public education of vehicle drivers	Improving traffic behavior, reduction of energy consumption and GHG emissions
M18	Effective use of telecommunications	Reduction of travel demand
Measures for the far Future (Fuel Switching)		
M19	Road Vehicle with alternative fuels	Reduction of GHG-emissions
M20	Electric car / Electric bus	Reduction of GHG-emissions

For the calculation of the transport activities, travel demand models are needed. The models can also be applied to predict the effects of measures with "modal shift and travel demand reduction" objectives.

It is very difficult to predict the effects of the measures with other objectives, such as fuel switching, energy saving, public education of vehicle drivers, and vehicle maintenance. In this case, the measure effects can roughly be estimated by applying limited experiments or by investigating the results obtained from countries which already carried out such measures [10].

5. CASE STUDY: EGYPT

5.1 General

In Egypt, there are no earlier studies about the transport-related emissions on the sense of the previous presentation. Thus, the paper illustrates here an application of the proposed estimation method and evaluation process to Egypt, case study, in order to (1) estimate the amount of the CO_2 emissions (as one of the GHG emissions) contributed from the different transport modes, (2) compare the amount of the CO_2 emissions generated from the different transportation systems, and (3) prepare and analyze different scenarios needed for reducing the CO_2 emissions in the year 2020.

5.1 The National Context

Although Egypt is essentially rectangular in shape, the predominant feature from the transportation point of view is the linear configuration of economic activities, following the course of the Nile over the length of Egypt from south to north. The total population of Egypt in 1990 is estimated to be about 53.35 million people.

The topographical and geographical conditions in Egypt in combination with its very high population densities in the arable areas present a highly favorable environment for the transport of goods and passengers in the Delta and along the Nile in Upper Egypt. It is therefore not surprising that an extensive multi-mode intercity transportation systems have been developed.

Highways are the most important mode of transport system. The highways, with about 12 000 kilometers of paved roads and 14 000 kilometers of unpaved, carried in 1990 approximately 83 % of the total ton kilometers transported by all modes and also 66 % of the total passenger kilometers.

The railway system consists of 3905 route kilometers. It accounted for 10% of ton kilometers and 34 % of passenger kilometers in 1990.

The inland waterway system in Egypt is primarily an irrigation system and its physical characteristics are basically determined by irrigation requirement of the area served. From the transportation point of view, one link of the network (from the port of Alexandria to Aswan) is the most important axis. The rest of the network is occasionally used for transporting relatively small quantities of goods. The inland waterway system carried approximately 7 % of the total ton-kilometers.

The Egyptian port system consists of three major ports (Alexandria, Port Said, Suez) and a number of smaller ports. The three major ports handled approximately 25.5 million tons in 1990, of which 22 million tons were imports.

The civil aviation system consists of 15 airports with approximately 60 000 aircraft and 10 million passengers in 1990. Cairo airport handled approximately 6.7 million passenger movements.

5.3 Energy Consumption Of The Different Economic Sectors

According to the official published statistics, the prime energy consumed by the transport sector in the year 1990 was about 18.0 % of the total energy consumption of the different economic sectors. Thus, the transport sector in Egypt is the third largest prime energy consumer after electricity production and industry Figure (2).

The specific energy consumption for different transport modes in Egypt was based on data collected from the statistics of different sources, taking into consideration vehicle occupancy rates in Egypt [11,12,13]. The specific energy consumption was calculated in terms mega joule per passenger-kilometer (MJ/pkm) for passenger transport or per ton-kilometers (MJ/tkm) for freight transport.

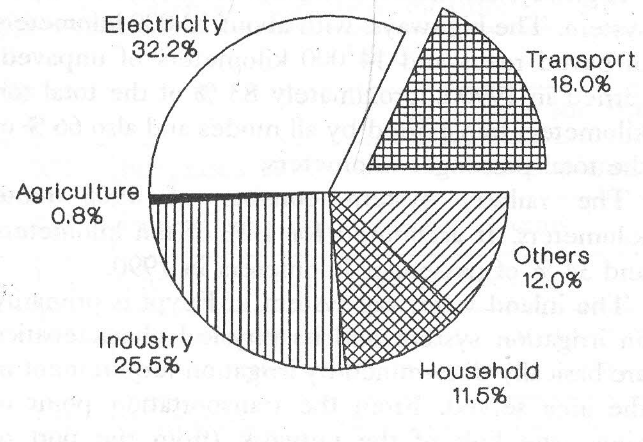

Figure 2. Actual Distribution of the Prime Energy Consumption, Egypt 1990

The CO_2 emission rates were then calculated in gram emission per passenger-kilometer or per ton-kilometer, based on data collected about the quality of different types of fuel used in Egypt [14].

Figure 3 (a and b) presents the specific energy consumption and CO_2 emission rates for various transport modes under different conditions (short distance and intercity transport).

As might be expected private cars have the highest specific energy consumption in MJ/pkm, particularly for short distance transport (Figure 3-a). Intercity trains and buses are the most efficient energy consumers. In case of freight transport, intercity trains and boats are again the most efficient energy consumers in terms of MJ/tkm. Semi-trucks represent, on the other hand, the least efficient mode for freight transport.

Figure (3-b) is almost a mirror of Figure (3-a) in that it shows the specific CO_2-emission rates of the same mode of transport modes. The private cars emit almost ten times CO_2 per pkm more than corresponding public transport modes; i.e. buses and trains.

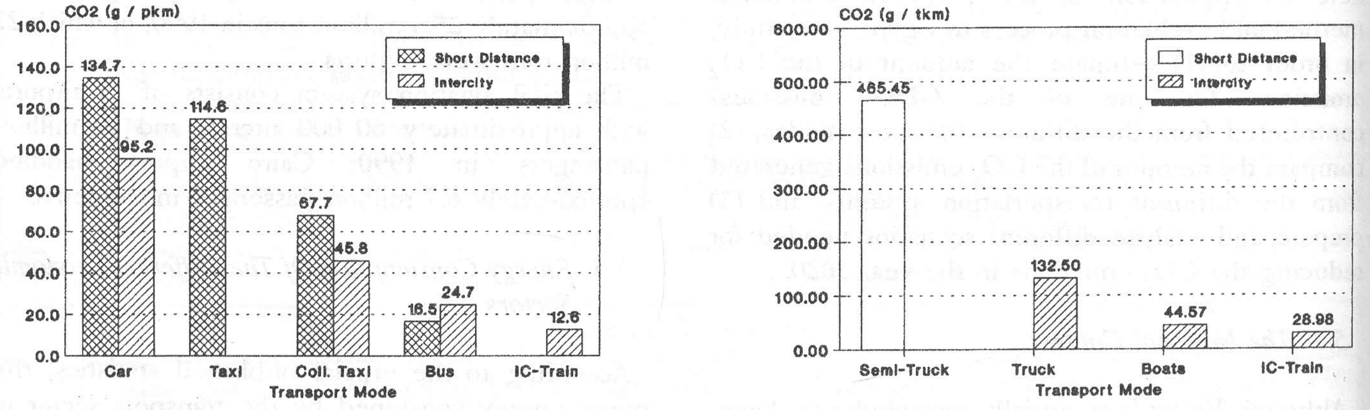

Figure 3-a. Specific energy consumption for different transport modes

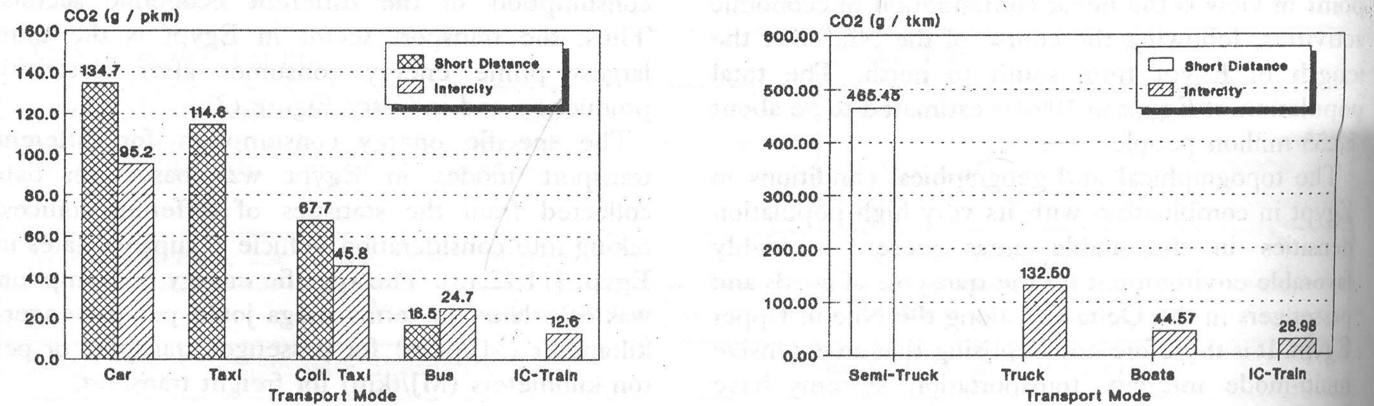

Figure 3-b. CO_2-Emission rates for different transport modes

Table 2. Specific Energy Consumption and CO_2-Emission Rates of Aircraft and Ocean ships

a) Aircraft

Transport Mode	Vehicle Capacity (Passenger)	Specific Energy Consumption		CO_2-Emissions
		Liter/100 km	MJ/veh.-km	g CO_2/veh.-Km
Aircraft (Boeing 727)	167	760.7	242.82	17 790

b) Ocean Ships

Ocean Ships	Daily Energy Consumption in tons				Daily Energy Consumption in GJ		Daily CO_2-Emissions in tons	
	At Port		At Sea		At Port	At Sea	At Port	At Sea
	Gas Oil	Fuel Oil	Gas Oil	Fuel Oil				
< 5 000 t	1.5	0	12.5	0	64.35	536.25	4.78	39.85
- 10 000 t	2.0	2.0	1.5	20	171.40	920.35	12.80	69.02
- 20 000 t	4.0	0.5	2.4	22.5	193.00	1065.96	14.36	79.92
> 20 000 t	4.2	1.0	2.1	22.6	223.00	1056.37	16.60	79.29

5.4 Reference Scenario (trend 2020)

Table 2 (a and b) gives the values of the specific energy consumption and CO_2-emission rates of aircraft and Ocean ships. The specific energy consumption was calculated in terms of liter per 100 km (l/100 km) and mega joule per vehicle kilometer (MJ/veh.-km). The CO_2 emission rates were calculated in terms of gram per vehicle-kilometer (g CO_2/veh.-km). The calculations were based on data collected from the Egypt Air Co. and the Egyptian Company for Maritime Transport.

The energy consumption and consequently the transport-related emissions depends mainly on the transport demand. For road, rail, and water transport, it is assumed here that the increase of demands will match the projected population growth, while for air and maritime transport, the demand increase will be based on the expansion of the number of vehicles.

Figure (4) shows the development of CO_2 emissions in Egypt until 2020 under the reference scenario for the different transport systems. It can be seen, that with an average growth rate of about 3.1 %, the amount of CO_2 emissions will achieve 25.89 Million tons in the year 2020. The Break down of these emissions among the various transport systems illustrates that the road will be the main contributor of CO_2 emissions; about 90 % of the total transport-related emissions. This will be followed by rail, and maritime transport; 5.3 % and 3.4 % respectively.

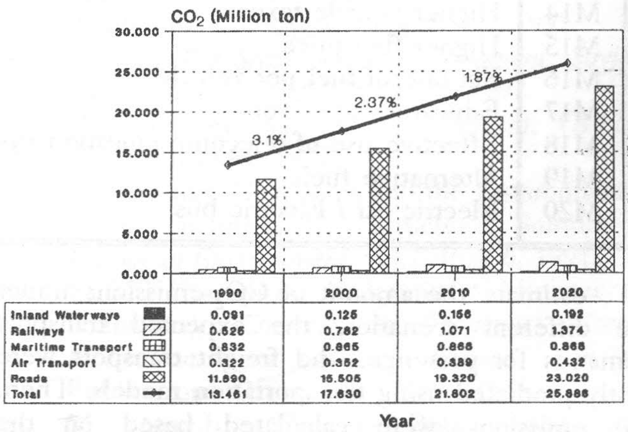

Figure 4. Prediction of CO_2-emissions in Egypt until 2020

5.5 The Abatement Scenarios

Three abatement scenarios are then developed (as shown in Table (3): (i) Scenario A includes low-cost policy measures, (ii) Scenario B includes the measures of scenario A plus measures for upgrading the existing transportation systems under environment-oriented planning policies, and (iii) Scenario C includes beside the measures of scenario B, measures for fuel switching and reducing travel demands.

Table 3. Development of Scenarios by Combining the Measures proposed in Table 1 for the Reduction of CO_2-Emissions.

	Measures	Combination of Abatement Measures		
		Scenario A	Scenario B	Scenario C
M1	Land use/transportation planning	No	No	Yes
M2	Upgrading public transport	No	Yes	Yes
M3	Pedestrian facilities	No	No	Yes
M4	Improving road infrastructure	No	Yes	Yes
M5	Road pricing, etc.	Yes	Yes	Yes
M6	Priorities for bus and Coll. taxi	Yes	Yes	Yes
M7	Freight transport centers	No	No	Yes
M8	Electrification of railways	No	No	Yes
M9	Increasing the attraction of railways	No	Yes	Yes
M10	Improving inland waterways	No	Yes	Yes
M11	Combined freight transport	No	No	Yes
M12	Highway user fees	Yes	Yes	Yes
M13	Maintenance of vehicles	Yes	Yes	Yes
M14	Higher vehicle taxes	Yes	Yes	Yes
M15	Higher fuel price	Yes	Yes	Yes
M16	Fix-rate of fuel per vehicle	No	No	Yes
M17	Education of drivers	Yes	Yes	Yes
M18	Effective use of telecommunication systems	No	No	Yes
M19	Alternative fuels	No	No	Yes
M20	Electric car / Electric bus	No	No	Yes

estimate the amount of CO_2-emissions under different scenarios, the expected transport nds for passenger and freight transport were predicted using transportation models. Then, emissions were calculated based on the ;ponding specific energy consumption and the ıal emission rates.

ıre (5) presents the CO_2-emission differences e year 2020 under the various abatement rios from the situation in the year 1990 and the reference scenario (trend 2020). It can be that under scenario A, the amount of the CO_2-ions can be reduced by 19.6 % from the ions in the reference scenario, 28 % under rio B, and 50 % under scenario C.

ıre (6) shows the increase of CO_2-emissions (in between the year 1990 and the year 2020 under ifferent scenarios. It is assumed here that the ures of scenario A will be implemented by the 1995, and at the same time, the projects needed e realization of either scenario B or C would be started, if one of them is selected. The effects that can be achieved by scenario B or C would appear approximately by the year 2005. In the year 2020, the reduction of the CO_2-emissions from the reference scenario achieve for the scenarios A, B, and C the values 19.6 %, 28.6 %, and 50.0 % respectively.

Under scenario C, the reasons for the great reduction of CO_2-emissions in the year 2020 (50 %) are:

I. The great reduction in pkm due to: (a) land use/transportation planning and the effective use of telecommunication systems, and (b) the modal shift to the public transportation systems.

II. The great reduction of energy consumption as a result of: (a) fuel switching from fossil oil to electricity and natural gas.

It should also be noted that emissions generated from the production of electricity are not taken into account.

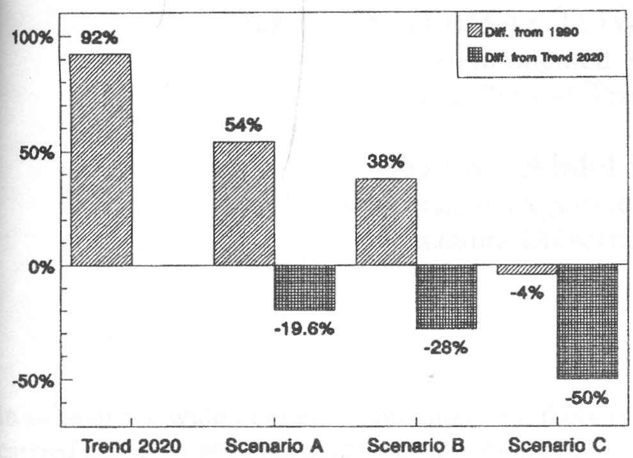

Figure 5. CO_2-Emission differences under the different abatement scenarios from the reference scenario (trend 2020) and the situation in the year 1990.

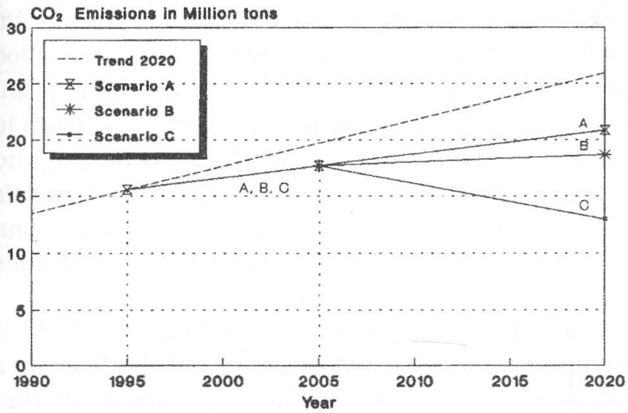

Figure 6. Development of CO_2-emissions under the different Abatement Scenarios until 2020.

6. CONCLUSION

The application of the proposed evaluation process with its multi-stepped program to the example of Egypt focused its practicality and usefulness for developing countries which prepare transport-related GHG emission inventories for the first time. The application demonstrated also the capability of the process by the preparation and the technical evaluation of GHG abatement scenarios to achieve a proper reduction of expected emissions.

Otherwise, the paper identified the main areas of uncertainties, which were coupled with specific recommendations on how to resolve such uncertainties and to improve the inventory data in a follow-up study.

In a follow-up study, the GHG abatement costs should also be investigated to enable the communities by deciding the best technical and economical solution. It is expected that the unit cost of reducing one ton of emissions raises rapidly with the increase of the amount of emissions needed to be reduced. Immense emission reduction should be based on large-scale environment-oriented projects.

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