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SOUTH AFRICAN ROAD TRANSPORT
REQUIREMENTS FOR SUSTAINABLE
GROWTH

by

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Thesis presented for the degree of DOCTOR OF
PHILOSOPHY in the Energy Research Institute of the
University of Cape Town.

7 September 2000

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Abstract

The assumption that ownership of private motor vehicles as a right is questioned. This thesis is based on the hypothesis that in fact in the case of South Africa this will have many detrimental effects if allowed to continue. It is argued that for sustainable growth, other more attractive options exist. Developments in more developed countries are examined in order to prove that similar conclusions have been reached.

The problem investigated in this thesis is therefore the non-sustainability of the continued growth of the private car population in South African urban centres. A literature survey was conducted on what other countries did with their transport problems but the same problem as in South Africa has not been encountered anywhere else in the world. South Africa therefore has a unique situation, which needs to be resolved in a unique way.

There is increasing awareness elsewhere in the world that the causes of most of the problems experienced in the transport sector are deficiencies in the efficient operation of markets. Environmental costs are neglected or underestimated in transport prices. As a result, the individual transport user receives distorted price signals. Failure to respect economic principles results in waste, characterised in the transport sector by high accident rates, health problems, negative environmental impacts, financial constraints in the public transport sector and an increase in congestion that persist because users perceive them only indirectly.

Motivations are provided to prove the hypothesis that public mass-transit systems will provide the optimal solution and examines options that will achieve this goal. This thesis investigates different options, which were successful in other countries worldwide and also analyses the current situation in South Africa. Analyses of the problems have been made and scenarios have been established of what the effect will be when different options are implemented in the South African situation.

One option that is explored in more detail is the diesel taxi midibus project which has recently commenced and for which there has not been general acceptance by the taxi drivers.

The following short term recommendations are proposed to alleviate the transport as well as the economic problems of South Africa.

- The petrol diesel price differential should be increased by as much as possible.
- The taxi minibus industry should receive continued assistance from government.
- Leaded petrol must be phased out as soon as possible.
- Catalytic converters must be made mandatory for all new vehicles. This includes particulate traps for all new diesel vehicles.
- Town and Regional planning must plan for denser urban centres and urban sprawl should be avoided at all costs.
- Information to and education of end users are essential to promote the advantages of public transport systems.
- Company vehicle schemes must be reinvestigated to minimise travel.
- Safeguarding the current rail services and promoting the use thereof is essential.
- Increased road side vehicle emissions tests should be instituted.

Medium to long term recommendations include the following:

- High speed rail, especially for the areas outside the perimeter of cities, with a circular feeder system as well as between Metropolitan areas e.g. Johannesburg, Midrand and Pretoria. The planning for these should commence as soon as possible. It must be a parallel approach with the short term solutions.
- The enforcement of traffic regulations and the Air Pollution Act is essential.
- Retrofitting of three way catalytic traps and catalytic converters to other vehicles (especially urban buses and government vehicles).

- Maintenance projects for all old vehicles and a possible old vehicle scrapping project.
- Alternative fuels such as natural compressed gas should be investigated.
- Special programmes to place workers nearer to workplaces should be implemented.
- Alternative technologies e.g. hybrids and series hybrids could be further investigated for South African purposes.

By so doing the following problem areas will decrease:

- Accidents
- Air pollution
- Viability of public transport
- Stranded people
- Congestion
- Health problems in urban areas

The thesis proceeds to give reasons for the above mentioned priority areas for South Africa, which could be implemented to restrain the use of the private car and to encourage the use of the public transport system.

The implication is that a transport system must be built which does not shift the burden of millions of people without transport onto future generations, and this will require bold political choices. Today's generation must have the courage to take the necessary measures and build a sustainable society, in other words a society which meets the present generation's needs without jeopardising future generations' ability to meet theirs.

NOMENCLATURE

AC	Alternate current
CARB	California Air Resources Board
CBD	Central Business District
CFC	Chloro Fluoro Carbon
CH ₄	Methane
CNG	Compressed natural gas
CO	Carbon monoxide
dB	decibels
DC	Direct Current
DOT	Department of Transport
EEC	European Economic Commission
ECC	Environmental concept car
EPA	Environmental Protection Agency
EPEFE	European Programme on emissions, Fuels and Engine technologies
ESAL	Equivalent Standard Axle Load
ETBE	Ethyl-t-butyl ether
EU	European Union
EV	Electric vehicle
g/bhp-hr	grams per brake horse power hour
GDP	Gross Domestic Product
gpm	grams per mile
HC	Hydrocarbons
I/M	Inspection and maintenance
IC	Internal Combustion
km	kilometres
km/h	kilometres per hour
kW	kilowatt
LCA	Life Cycle Assessment
LDV	Light delivery van
LEV	Low emission vehicle
LNG	Liquefied natural gas
LPG	Liquefied petroleum gas (propane and butane)
M	million
MN	Minneapolis-St Paul
MNL	Maximum Noise Level
MTBE	Methyl-t-butyl ether
NGV	Natural Gas Vehicle
NMHC	Non-methane hydrocarbons
NO _x	Nitrous oxides
OBD	On board diagnostic
OECD	Organisation for Economic Co-operation and Development
PEMFC	Proton exchange membrane fuel cell

PM	Particulate matter
PNGV	Partnership for the Next Generation Vehicles
ppm	Parts per million
PSA	Peugeot Societe Anonyme
rpm	revolutions per minute
RSA	Republic of South Africa
SABS	South African Bureau of Standards
SADC	Southern African Development Community
THC	Total Hydrocarbons
TLEV	Transitional low emission vehicle
UK	United Kingdom
ULEV	Ultra low emission vehicle
UNECE	United Nations Economic Commission for Europe
US	United States of America
USEPA	United States Environmental Protection Agency
V/C	volume to road capacity ratio
VED	Vehicle excise duty
VKT	Vehicle kilometres travelled
VMU	Vehicle management unit
VOC	Volatile organic compound
WHO	World Health Organisation
ZEV	Zero emission vehicle

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Chapter 1: Introduction and Background

1.1. Introduction

The economic changes in the developed countries, and to a lesser extent also in the developing countries, have been largely responsible for the rising demand for the transport of people, goods and services in urban areas. People have moved from homes in the city centre to suburbs, either because of increased affluence or as a result of misguided planning decisions of the past. Places of work have moved from town centres to dispersed industrial estates and out-of-town shopping areas. Commuting demand has increased but public transport has not met the need. Crime rates have increased and travellers feel more secure in their cars than on public transport. This same concern over safety applies to parents driving children to school. Schools are fewer, but larger, and serve a wider area. One of the results of greater affluence is that people demand more products, which not only require transport from factory to retail outlet to home, but also require transport for servicing and eventual disposal. These and many other factors contribute to the ever-growing demand for increasing mobility of people, goods and services.

All major urban areas throughout the world now experience congestion, atmospheric pollution and noise as a result of traffic. In some cities the climatic conditions are worse and so they have more immediate problems, but levels of atmospheric pollution due to the transport of people and goods are causing serious concern for the health of the population in thousands of urban areas around the world. Furthermore, recent evidence shows that rural areas hundreds of miles downwind of urban areas can also be subjected to high levels of pollution, not only from acid rain, but also from health-damaging concentrations of fine particles, ozone, oxide of nitrogen, etc. from vehicle exhausts.

A description of the effects of vehicle emissions on human health¹:

Particles

Evidence has accumulated during the past ten or so years to show that day to day variations in concentrations of airborne particles, measured as PM10, PM2.5, Black Smoke or other measures, are associated with day to day variations in a range of health end-points. These include daily deaths, admissions to hospital for the treatment of both respiratory and cardiovascular diseases and symptoms amongst patients suffering from asthma. In addition to these effects there is evidence from the United States that long term exposure to particulate air pollution is associated with a decrease in life expectancy.

Sulphur Dioxide

Sulphur Dioxide is an irritant gas that, in high concentrations, provokes bronchoconstriction: i.e. narrowing of the airways. Epidemiological studies have shown, as in the case of particles, that concentrations of sulphur dioxide are associated with a number of deaths occurring each day and also with admissions to hospital for the treatment of respiratory diseases in the UK. There is also evidence linking concentrations of sulphur dioxide with chest symptoms and with the use of bronchodilator therapies. There is evidence from the United States that long term exposure to sulphate particles may increase the risk of death. Sulphates are produced by oxidation of sulphur dioxide.

Nitrogen Dioxide

UK work has shown that exposure to nitrogen dioxide enhances response to allergens and may increase the prevalence of respiratory infections in children. Volunteer studies have shown effects on lung function in asthmatics. It should be noted that nitrogen dioxide can be converted to nitrate which is a component of the particle aerosol.

Ozone

Evidence linking daily deaths and admissions to hospital with daily average concentrations of ozone is strong. It is not known whether there is a threshold for the effects of ozone on health. Volunteer studies have shown irritation of the airways. There is evidence from US studies that long term exposure to raised ozone concentrations accelerates the decline in lung function with age and may impair the development of lung function.

Lead

Lead is known to damage the developing nervous system and blood lead concentrations have been shown to be inversely related to IQ. There is no apparent threshold for this effect. Blood lead concentrations have been shown to be related to air lead concentrations. There is also evidence to suggest that raised blood lead concentrations are related to increased blood pressure.

A description of the non-health effects of vehicle emissions:²

Sulphur dioxide (SO₂)

SO₂ emissions (and associated secondary pollutants) have been linked to a wide range of impacts on several receptors. These effects are summarised in Table 1 below.

Table 1 Environmental effects linked to SO₂ and Secondary Pollutants

Pollutant	Effect
SO ₂	Damage to 'utilitarian' buildings Damage to historic buildings and objects of cultural value Direct effect on crop yield Forest damage Indirect effects on crops and on trees through interactions with pests, pathogens, climate and other pollutants Ecological damage
Sulphate aerosols	Reduced visual range
Acidic deposition	Damage to 'utilitarian' buildings Damage to historic buildings and objects of cultural value Acidification of agricultural soils Acidification of forests, freshwaters and other semi-natural ecosystems and associated effects (change in species diversity etc.)

Sulphur Dioxide and material damage

The effects of atmospheric pollutants on buildings has been well documented over many years and clear mechanisms linking pollution to material damage have been identified. Sulphur dioxide has emerged as the key pollutant associated with material erosion, both directly (through dry deposition) and indirectly through the formation of secondary pollutants (acidic deposition). These damages have been recorded on modern buildings and other modern infrastructure as well as historic buildings.

Sulphur Dioxide and Crops

Although ozone is regarded as the main pollutant of concern with respect to crops, sulphur dioxide can also influence crop yield or quality. The effects of SO₂ can be both positive and negative, through both direct and indirect mechanism, and include changes to soil acidity (via deposition), reduced crop fertilisation from deposition, and impacts on pests and diseases from ambient concentrations. SO₂ has been shown to damage crops directly at high pollutant concentrations.

Nitrogen Dioxide

Emissions of NO_x (and secondary pollutants such as nitrate aerosols and acidity) are associated with a wide range of impacts to several receptors. These effects are summarised in Table 2 below.

Table 2 Environmental effects linked to NO_x and Secondary Pollutants

Pollutant	Effect
NO _x	Direct effect on crop yield Forest damage Indirect effects on crops and on trees through interactions with pests, pathogens, climate and other pollutants Reduced visual range
Nitrate Aerosols	Reduced visual range
Acidic deposition	Acidification of ecosystems and associated effects (change in species diversity, loss of fish, etc.) Damage to building materials Damage to historic buildings and objects of cultural value
Nitrogen deposition	Eutrophication of ecosystems and associated effects (change in species diversity, productivity, etc.)

Particulates

Emission of particulates is associated with a range of impacts to several receptors. These effects are summarised in Table 3 below. The soiling of buildings by combustion particles is one of the most obvious signs of pollution in urban areas. The soiling of buildings includes both residential dwellings and historic buildings and causes economic damages through cleaning costs and amenity costs. Particles may also be involved in damage to the building fabric.

Table 3 Effects linked to emissions of particulates

Pollutant	Effect
Particulates	Building soiling Damage to 'utilitarian' buildings Damage to historic buildings and objects of cultural value Reduced visual range

Ozone

Ozone is associated with a wide range of impacts on several receptors. These effects are summarised in Table 4 below. Ozone is known to damage some polymeric materials such as plastics and rubbers.

Table 4 Environmental effects linked to Ozone

Pollutant	Effect
Ozone	Damage to materials (e.g. paint rubber, textiles etc.) Direct effect on crop yield Forest damage Indirect effects on crops and on trees through interactions with pests, pathogens, climate and other pollutants Other ecological damage

Ozone is regarded as the main pollutant of concern with respect to crops. There is a wide range of different impacts that air pollution can have on crops, e.g. increased sensitivity to disease.

South Africa

In South Africa growing air pollution is a major concern. The new South African constitution sets a national goal of a clean and healthy environment for all. This implies that the government will have to set norms and standards

for the different kinds of pollution that occur daily in South Africa. The Reconstruction and Development Programme states that "...future emphasis must be on the provision of safe, convenient, affordable public transport. Commuters should be encouraged to use public transport, and should be actively discouraged from using cars (via economic initiatives). The funds so raised must be used to directly benefit the provision of public transport." This is good news for South Africa's economy, environment, and social empowerment goals. However, this has not yet been implemented.

Although most cities have some problems with air pollution, there are large variations in the scale of air pollution and in the relative importance of different pollutants. Pollution levels change from season to season. In most cities they have also changed over the last 20-30 years, reflecting changes in fuel use, economic structure and, in some cases, tighter environmental regulations. For instance in most cities in Europe and North America, it is no longer the traditional pollutants from the combustion of coal or heavy oil that are the main problem. Motor vehicles have become the major source of air pollution, as the number of motor vehicles in use has risen rapidly (and so too have conditions that exacerbate motor vehicle pollution such as congestion). At the same time legislation has resulted in a decrease in the levels of traditional industrial pollutants.

South Africa is currently still experiencing the results of the use of traditional energies such as coal and paraffin but the motor vehicle pollution will become more important with time as more and more houses are being electrified. This process has already commenced and grid electrification has almost reached its goal.

1.2. What is currently being done world-wide

Controlling the impact of the motor industry on the environment has been the focus of countries around the world for a number of years. The US has led the way with legislation on 'local' pollution. Europe's prime concern had been 'global' pollution, especially the greenhouse effect. By the early 1990's,

transport policies in some European countries were being carefully scrutinised. Policies, aimed initially at reducing congestion in cities, are being re-examined from the point of view of reducing vehicle emissions deemed to be harmful to health. Elsewhere in the world, for example, in developing Asia, there is a growing awareness of hydrocarbon pollution at the 'local' level.

The introduction of catalytic converters to reduce NO_x, carbon monoxide and hydrocarbon emissions had a major impact on the oil refining industry in the US and Japan, and subsequently in Europe. It effectively marked the beginning of the demise of the use of lead ethyl or methyl for gasoline octane enhancement. This meant that, in some regions, a previously relatively cheap source of octane improvement had to be replaced with more expensive blending components, necessitating considerable investment in refineries.

South Africa started this process by introducing unleaded petrol in February 1996 not for environmental reasons but merely as we are importing technology and had to stay in line with the rest of the world's technologies. The vehicle manufacturing industry in South Africa had to comply with the changes in the mother companies in Europe and Japan. South Africa is one of the major producers of catalytic converters due to platinum being a resource of South Africa but unfortunately these are only exported and not fitted to South African vehicles due to South Africa not having any requirement currently for the fitting of catalytic converters.

Legislation to control the exhaust emissions from road vehicles in Europe began with the United Nations Economic Commission for Europe (UNECE). It produced voluntary regulations, beginning in 1970 with the regulation of 'visible' emissions in the form of smoke, particularly from diesel vehicles, based on the relevant UK Construction and Use Regulation 61 of 1968. This Regulation 61 was subsequently updated and embodied in a British Standard. It is still the regulatory standard for diesel exhaust smoke.

EU emissions legislation for light commercial vehicles and heavy-duty vehicles ('the clean lorry directive') has been in place since 1993. Since implementation in 1996, emissions legislation has been comparable to existing US legislation.

Some countries, notably Sweden, Austria and Switzerland, have introduced US exhaust emission standards in advance of EU legislation and other countries have adopted a form of gasoline reformulation, ahead of any EU decision on the subject.

Prompted by health fears in some countries and by the move to the introduction of catalytic converters in others, there has been a gradual trend towards unleaded gasoline sales throughout the world, but this has been particularly marked in the US, Japan and Western Europe. Leaded gasoline has been banned in the US since January 1995 and in California and Canada since December 1990. Most countries have provided tax incentives to encourage the use of unleaded grades. In all European countries, leaded gasoline has been banned. Austria has banned leaded gasoline sales since October 1993, and sales in Sweden were banned in July 1995. In the Far East and Middle East, unleaded gasoline penetration is increasing. Japan has been totally unleaded since the early 1980's. Brunei, Thailand, Turkey and the UAE have also introduced unleaded gasoline. Latin America, Mexico and Brazil have had unleaded gasoline for some years and Chile, Argentina and Guatemala introduced it in 1991-1992.

Measures to curb congestion and air pollution in cities, which occur as a result of vehicle emissions, have also been introduced world-wide. This includes traffic demand measures, research and development into new technologies for fuel efficient and environmentally sensitive engines, exhaust pipe systems and alternative fuels.

1.3. Effects of transport

Significant growth in the demand for, and supply of, transport infrastructure and services has occurred over the past 20 years. While transport services are an essential component of economic and social development, negative side effects are causing considerable concern and drawing political attention to the social costs of transport.

Pollution, accident costs, degradation of landscapes and ecosystems and reduced quality of life have long been of concern. Congestion and uncovered infrastructure costs have become the subject of particular attention more recently. These problems cause significant and unnecessary welfare losses to the economy and society.

There is increasing awareness that the root causes of most of these problems are deficiencies in, or barriers to, the efficient operation of markets. Environmental costs and other externalities are systematically neglected or underestimated in transport prices. As a result, the individual transport user receives distorted price signals. Failure to respect a fundamental economic principle results in waste, characterised in the transport sector by high accident, health, environmental, finance and congestion costs that persist because users perceive them only indirectly.

However, some means of transportation of people in cities are essential. Chapter 5 of this thesis focuses on the midibus as it has a specific role in public transport in the urban centres of South Africa. It is predominantly an urban and semi-urban, low capacity mode. It travels on short to medium routes of 10 to 20km, with a high trip frequency of approximately 10 trips per day.³ Because of its low capacity it is most effective during off-peak periods, when fewer passengers use public transport. It is very effective in providing transport to hotels or inner city centres as a shuttle service.

It is uneconomic to use buses in the above circumstances; the cost of running a bus stays constant even when the passenger demand is low. On the other

hand, minibuses have lower running costs and are able to meet the demands of passengers.

Midibuses are therefore ideal for urban operation, as their running costs are lower than those of buses, while they still provide adequate space for the number of passengers.

1.4. South African situation

The population of South Africa is becoming increasingly urbanised. As the South African economy changes, the combination of increased disposable income, inadequate provision of safe, affordable, and convenient transport services (buses, tramways, cycling and pedestrian facilities) and urban sprawl from dispersed residential, commercial and industrial development, results in an increasing number of private passenger vehicles on the road. The combination of these dynamics also results in the concomitant levels of automobile emissions, traffic congestion, and increased consumption, and dependence on oil imports.

Urbanisation could be ascribed to the fact that there are not enough job opportunities in the rural areas and that the perception exists that jobs are easily obtainable in the cities. This has the result that squatter camps are emerging at a concerning rate. There is also the perception in neighbouring countries that South Africa has jobs for all and therefore this creates further pressure on the already inadequate transport system in South Africa.

The geographic separation of people on the basis of race is an economically costly legacy of apartheid. For decades, apartheid planners systematically, and in accordance with South African law, placed Blacks in “townships” far from city centres, and far from white suburban enclaves. The central business districts of South African cities are surrounded by rings of under-utilised land, also known as peri-urban areas, which used to serve as an economic, social and psychological buffer zone between races. At the extreme periphery lie the

sprawling settlements known as townships that are home to approximately three-quarters of South Africa's black population.

Law until 1994 banned economic activity in the townships, except for the provision of basic needs, reducing the availability of legal employment. This meant that black people had to commute to far off white-dominated urban centres to work, to acquire their material needs, and to access basic amenities that in other cities would be handled locally. An unintended result of apartheid policy was the formation and rise of a thriving informal, or underground, economy with its commensurate advantages and disadvantages to national prosperity.

Separation of races within urban space was such a pillar of the apartheid system that policy makers and the private sector were willing to tolerate the enormous costs and inefficiencies associated with the black labour force travelling long distances back and forth from townships to the cities each day. Most of these costs were, and still are, paid by black people in terms of time spent and the physical difficulty of few affordable options for long-distance commuting. Because most black people could not afford to pay the full cost of commuting each day, the government subsidised (and still subsidises) rail and bus transport between the townships and employment centres. Thus, the spatial inefficiencies of the post-apartheid city continue to have costs paid by Whites and Blacks alike.

1.5. Pressures on government to change

Some of the pressures include the following:

1. The shift to democracy has opened doors for many organisations (for example non-government organisations and community based organisations) to have some input into the formation of the public policies that will affect them. South Africa is experiencing a rise in such public interest institutions seeking to influence government. Non-governmental stakeholders include transport, energy, and the

environment research institutions, environmental and civic groups, and the private sector.

2. It is the growing environmental awareness of the ordinary consumer that has the biggest impact on the direction in which oil companies world-wide are moving. Consumers are concerned about both global issues, e.g. the greenhouse effect and acid rain, and 'local' issues e.g. photochemical smog, lead and particulate emissions. The existing measures to control and combat air pollution are not sufficient and are mostly not enforced.
3. The larger majority of the South African urban and rural population are still waiting for their basic needs to be met e.g. houses, energy, water and sanitation. Therefore these people are not concerned about the environmental impacts of transport.
4. Although it is not enforced, South Africa does have a pollution control Act but it is not nearly as stringent as the European and US Acts.

A summary of the different pollution control Acts:

In accordance with section 20 of the Health Act (Act 63 of 1977), it is the responsibility of local authorities to maintain hygienic and clean conditions in areas under their jurisdiction. Conditions which they have to combat are those which may be regarded as a nuisance, such as offensive smells and air pollution, but also conditions that may be potential health hazards.

Air pollution is regulated by the Atmospheric Pollution Prevention Act, 1965 (Act 45 of 1965). The Act is administered by the Department of Health and is subdivided into six parts in order to make provision for the control over harmful or annoying gases from industrial processes, smoke, dust and motor vehicle exhaust fumes. Part V of the Act makes provision for the control of air pollution resulting from fumes emitted by vehicles. Local authorities exercise control over this part of the Act where such authority has a test centre and the

appropriate measuring instruments. These are, however, not readily available in all Local Authorities in South Africa.

Control is at present exercised only in respect of diesel vehicles. In the case of diesel-driven vehicles, the danger of motor accidents resulting from excessive smoke discharge is also taken into account.

The Chief Health Officer remains responsible for law enforcement in terms of the Atmospheric Pollution Prevention Act (Part V). Fumes emitted by vehicles can be controlled only in areas under the jurisdiction of a local authority that have been declared controlled areas by the Minister of Health. In terms of the Act, vehicles suspected of emitting fumes may be examined and repairs may be required.

Initially therefore, there is no penalty if a vehicle emits excessive fumes, but if the owner of such a vehicle fails to comply with the provisions of the notices, he will be guilty of an offence. At present control is exercised in 39 of the most important towns and cities.

This measure differs from provincial legislation in the respect that inadmissible air pollution by a vehicle directly constitutes an offence in terms of the provincial measures while in terms of the Atmospheric Prevention Act, it is the owner of the vehicle that pollutes the air who can be called upon to rectify the matter. In the latter case the degree of air pollution can be measured according to a fixed criterion. This statutory provision is therefore preferred to provincial legislation, since it is more effective to compel someone to have his vehicle examined, thus preventing air pollution from exceeding the permissible degree, than merely to penalise him for excessive air pollution.

Apart from the above-mentioned measures, there are other local authority bylaws which authorise the Chief Health Officer of the town or city concerned to take steps against air pollution.

In spite of control measures to combat air pollution at the source, certain amounts of pollutants still escape. Added to this there is always the danger of a defect or an accident as a result of which dangerous pollutants can be discharged into the atmosphere.

In the planning of townships and the siting of installations that have the potential to pollute the air, due regard must be given to the reconciliation of polluted air with other land uses in the neighbourhood. Geographical factors that may influence, or be influenced by air pollution, should also be taken into account. The suitability of a site will depend largely on effective ventilation by atmospheric processes and the frequency of the potentially undesirable atmospheric conditions. For example, the siting of a town or a residential area in a valley may result in smog conditions. It is also desirable that industries which may cause air pollution should be placed down-wind of the prevailing wind direction of residential areas. These aspects are borne in mind the siting of new industries as provided in section 10(4) of the Atmospheric Pollution Prevention Act. ⁴

As the environment is considered a major attribute of South Africa, more input is expected from environmental organisations regarding environmental aspects.

1.6. Aim

The purpose of this thesis is to prove the hypothesis that the uncontrolled growth in car ownership cannot be allowed and to provide recommendations to alleviate this situation in South Africa. This study further summarises research on transportation inefficiencies and the trends associated with it, to assist in policy making and planning in South Africa. This research is important in the light of the growth in automobile ownership that South Africa is currently experiencing. While this growth provides benefits to users, it also imposes costs on users and society. The majority of South Africa's citizens are not aware of the problems of increasing motor vehicle traffic, and

therefore it is necessary to investigate this issue and determine whether it should be a concern.

Until recently, most transportation professionals and economists assumed that increasing motor vehicle travel was essential for economic development and would need to be accommodated within cities. New research and economic analysis indicates that this is not necessarily true. Strong economies have developed with relatively low levels of automobile use, and there are indications that over-reliance on automobile travel may burden developing economies by reducing overall economic efficiency and shifting financial resources from investments to consumption.⁵ This is especially true of countries that import vehicles and fuel, like South Africa.

There is increasing realisation among transport professionals that motor vehicle traffic must be constrained under some circumstances, particularly in large urban areas, and that other travel modes, including public transit and bicycling, should be developed and encouraged as transportation alternatives. This statement will be investigated and analysed for the South African situation in this study.

This study provides the background for possibilities that exist to curb South Africa's transport inefficiencies by determining the trends of transport in South Africa and gives recommendations on what Government should do regarding the current transport situation as well as identifies the research that needs to be done in order to understand the situation in its full extent. South Africa has a unique history and the measures used overseas to curb such problems might not be feasible in South Africa.

1.7. Structure

The thesis consists of 6 chapters. The first chapter comprises a background and introduction into the current situation in South Africa. A literature study of world-wide examples to show the mistakes made follows. Following the literature survey, an investigation into the current situation in South Africa is

undertaken with specific reference to transport problems experienced. A detailed analysis of the road transport in South Africa is undertaken and life cycle analysis of vehicles in South Africa, production of oil in South Africa, environmental and health criteria are investigated. An economic analysis is part of this section. The following Chapter discusses different scenarios for South Africa and forecasting of pollution, congestion, accidents and densities is used to indicate the future expected trends if the status quo is allowed to continue and then "what if" measures are implemented to curb the problems being experienced. The penultimate chapter analyses government's endeavour to assist the taxi minibus industry in South Africa by indicating the positive effects this initiative could have on accidents, pollution, congestion and the viability of public transport. The last chapter recommends and defends policy options and levers, which should be implemented in South Africa to alleviate the problem.

Chapter 2: Literature Survey

2.1. Introduction

With the advent of the motor vehicle, new sources of atmospheric pollution and noise were created, but the rate of increase in the volume of traffic was slow in the first half of the 20th century. Certainly there were isolated places and times in some cities in the world where congestion occurred, but it was not recognised as a problem which could cause serious risks to public health. In that period there was little thought given to the problems of the effects of vehicle exhausts on city smog, acid rain, toxic emissions or even to the sustainability of fossil fuel supply.

Due to the fact that the major drivers for change in other countries were air pollution and health, concentration will be placed on these indicators. People around the world are generally not prepared to take public transport unless forced to do so as a private car has become a status symbol and even though petrol prices, parking fees etc. increase at an alarming rate, people still remain prepared to pay to be able to have the comfort of their own cars. Unfortunately a person's health and environmental health cannot be bought and that is why the focus in South Africa and in this thesis should also be health and environmental concerns.

2.2. Other countries

2.2.1. The United States of America

2.2.1.1. Background

In the 1940's the combination of particular climatic conditions in southern California and increasing use of the motor vehicle, resulting from the economic and industrial development of the area, produced a deterioration of air quality that caused concerns over public health and the quality of life. This led to the setting up, in 1946, of the South Coast Air Quality Management District, which had responsibility for implementing resolutions of the federal

and State Clean Air Acts in California's South Coast Air Basin. Air quality has improved since 1960, in spite of an 81% increase in the population, but this area is still considered to have the worst air quality in the US. Los Angeles was the only area to be identified in the 1990 federal Clean Air Act Amendments as an 'extreme' non-attainment area.

The need for federal legislation in the US to control urban atmospheric pollution developed in the 1960's, and led to the US 1970 Clean Air Act and the formation of the federal Environmental Protection Agency (EPA), which was charged by the federal government with investigating the sources of atmospheric pollution and developing the regulations that manufacturers and operators must follow to comply with the law.

It was established that emissions from transportation were the major cause of the pollution that caused smog and poor air quality in many US cities. The Office of Mobile Sources of the EPA was set up to advise the US government on the regulations that should be incorporated into legislation to control the emissions from mobile sources (on land, sea and air).

2.2.1.2. The US Clean Air Act 1990

In 1990 the US Congress passed the 1990 Clean Air Act, which strengthened many components of the US 1970 Clean Air Act as well as introducing several new clauses. Among these that were concerned with pollution from mobile sources were⁶:

- further control of ground level ozone (urban smog), carbon monoxide and particulate emissions from diesel engines;
- control of air toxins and acid rain
- the introduction of improved gasoline formulations to be sold in some polluted cities to reduce emissions of carbon monoxide and some ozone-forming hydrocarbons;
- the setting of standards for vehicle emissions to stimulate the introduction of even cleaner cars and fuels;

- consideration of emissions from non-road vehicles, including boats, farm equipment, bulldozers, lawn and garden devices and construction machinery: these non-road vehicles had not previously been controlled and were very 'dirty', accounting for some 15% of urban pollution;
- for the cities with the worst smog records, the introduction of limitations on growth of travel by encouraging alternatives to solo driving: employers were also required to find ways of increasing the average number of passengers in each vehicle for commuting and business trips;
- the promotion and encouragement of alternative means of commuting, such as walking or cycling and the use of mass transport.

The new law introduced many changes to vehicles and fuels, which add approximately \$200 (R1 223, (2000)) to the price of a new car and a few cents per gallon to the cost of fuel. However, they reduce most vehicle-related pollutants by about 40%. A requirement was introduced for new 1994 and later model cars to be fitted with on-board diagnostic systems (OBDS) which monitor the performance of the vehicle's emission control systems, advise the driver of any malfunction and store trouble codes to help mechanics identify the malfunction.

In more polluted cities it was necessary to introduce inspection and maintenance (I/M) programmes to check vehicle emissions on a regular basis.

2.2.1.3. Summary of Specific 1990 Clean Air Act Programmes

- The previous targets have been replaced by even higher standards.
- A Carbon Monoxide standard at certain temperatures was introduced to decrease cold start emissions in the winter.
- An increased oxygen content in the fuels are required in winter.

- Several new programmes to minimise the evaporation of hydrocarbons have been introduced e.g. vapour traps and a capping in gasoline volatility.
- Requirements for reformulated gasoline were introduced.
- Regulations for diesel emissions by buses were introduced.
- A specific number of clean vehicles had to be produced each year.

The cold-start and increase in oxygen levels will not be necessary in South Africa as the winters in South Africa are not that severe, however, evaporation, diesel emissions and clean cars are necessary in South Africa.

2.2.1.4. The California emission standards for cars and light duty vehicles

By 1990, the experience of the preceding 15 years had led the California Air Resources Board (CARB) to pass further low emission vehicle standards and clean fuel regulations. These standards require vehicle manufacturers to produce progressively cleaner light and medium duty vehicles for sale in the State of California. Commencing with the standards previously adopted for the 1991 and 1992 model years, an interim reduction of 36% in emissions of hydrocarbons and 51% of oxides of nitrogen was required to be phased in, starting with 40% of the vehicles sold in the 1993 model year.

Progressively cleaner vehicles were placed in four categories:

- transitional low emission vehicle (TLEV)
- low emission vehicle (LEV)
- ultra low emission vehicle (ULEV)
- zero emission vehicle (ZEV).

2.2.1.5. Inspection and maintenance programmes

Legislation to improve the emissions performance of vehicles by the manufacturers is of limited usefulness unless the higher standards are maintained throughout the operating life of the vehicle. Poor maintenance or malfunctioning emission controls can cause emissions to increase greatly. It

is the US experience that the average car on the road emits three or four times more pollution than standards allow for new cars. The percentage of dirty vehicles increases with age. Approximately 30% of five-year-old cars emit excessive pollution while at seven years old, the average age of passenger cars in the US, 55% are high emitters.

Unfortunately it is not always obvious which vehicles are producing excessive emissions and emission control malfunctions do not necessarily affect vehicle driveability. Inspection and maintenance (I/M) programmes have been designed to ensure that vehicles stay clean by carrying out periodic vehicle checks and requiring repairs to non-conforming vehicles. This encourages proper maintenance and discourages tampering with emission control devices.

The I/M programmes will be assisted by new technologies, including on-board diagnostic (OBD) systems using the vehicle computers to monitor the operation of emission control and warn the driver if maintenance is required. Diagnostic systems have been required on vehicles starting with model year 1994. OBD checks are required within the I/M tests because they too can malfunction, be tampered with, or simply be ignored. Remote sensing devices have been developed which can identify high emitting vehicles by taking a 'snapshot' of a vehicle's emissions as it passes a sensor located on the side of the road. These can supplement the I/M programmes but not replace them.⁷

Even though the US air pollution controls are most effective, air pollution problems are still being experienced. Automobile dominance creates a set of problems, such as congestion, pollution and accidents that coming decades will have no choice but to seek transport alternatives.⁸

2.2.1.6. Other measures to curb air pollution

Other efforts to alleviate the air pollution problem were based on the clear demonstration of the adverse health effects of lead in the atmosphere. It

resulted in the banning of leaded petrol. There has been no evidence that any damage has resulted to vehicles in the country as a result of unleaded petrol.⁹

The advantages of using public transport are well known in the US as the emissions savings are significant. Since light rail has electric engines, pollution is measured not from the tailpipe, but taking into account power plant emissions. For typical US commuters, rapid rail emit 30 grams of nitrogen oxides for every 100 passenger-kilometres compared with 43 grams for light rail, 95 grams for transit buses, and 128 grams for single-occupant automobiles. Public transport's potential for reducing hydrocarbon and carbon monoxide emissions is even greater.¹⁰

However, the cost of providing public transport is the overriding factor in government's decision making and many public officials fail to make a full accounting. A fair comparison must include a calculation of the full costs of both systems, including their environmental impacts and social consequences, and a consideration of which approach can move the most people. With public transports' lower impacts, higher capacities, and greater affordability for the general public, governments could get more for their money.¹¹

Unfortunately, some cities in the United States make little use of alternatives to the private automobile. Less than 5% of US work trips are by public transport, although large metropolises such as New York City and Chicago provide extensive public transport services. Nearly one-quarter of the entire country's public transport trips are in New York City. Fortunately several large and medium-sized US cities are either building or considering light rail systems, and others are adding light rail to their existing lines.¹²

One must also consider the implications of automobile dependency on the land use of a country. Land use patterns should be changed from road building approaches to land use patterns to reduce the need for driving. In the

long term, reducing automobile dependence calls for a fundamental re-evaluation of the shape of cities.¹³

The idea of land use patterns that have to change is not a new one. Colin Buchanan wrote the following in 1963. "There must be areas of good environment, urban rooms - where people can live, work, shop, and move around on foot in reasonable freedom from the hazards of motor traffic, and there must be a complementary network of roads - urban corridors - for effecting the primary distribution of traffic to the environmental areas. These areas are not free of traffic - they cannot be if they are to function - but the design would ensure that their traffic is related in character and volume to the environmental conditions being sought. It is a simple concept, but without it the whole subject of urban traffic remains confused, vague, and without comprehensive objectives."¹⁴

As a result of the continuation of the air pollution problems even while air pollution standards have been formulated, the US investigated other options to alleviate the problem. One of the other options is reformulated gasoline. The use of reformulated gasoline is being credited with reducing peak ozone levels in California. Ozone was reduced by 10 to 18% during the smoggiest days in June, July and August 1996 after allowing for differences in weather between 1995 and 1996.¹⁵

Another alternative fuel is LPG (propane) which may still be the most widely used alternative fuel in California, but most of the 45 000 vehicles that use it date from prior to 1992 when new rules forced converters to re-evaluate this option. The California Air Resources Board (CARB) required all engines and conversions to be certified in a stringent process that costs around \$200 000 (R1 223 000, (2000)) for an engine family.

The progress made in the field of electric vehicles could be ascribed to the monetary value the US applies to it. Unique Mobility won a \$1.23 million

(R7.52 million, (2000)) award to develop an advanced electric traction drive system for an ongoing transit bus project. ¹⁶

The United States, as other automobile dependant countries, has an economic and political vulnerability especially in the event of an oil crisis. The US uses 43% of its petroleum to fuel cars and light trucks and imports half of all its oil. Severe problems were experienced in August 1990 when Iraqi President Saddam Hussein's troops invaded Kuwait, claiming control over nearly 20% of the world's proven oil reserves. As a result of this the Middle East may never again be counted on for a stable supply of oil. Even in a stable market, increasing reliance on foreign oil weakens economies. ¹⁷

To curb pollution is a costly exercise. The California Air Resources Board (CARB) issued emissions reduction cost estimates, claiming that mobile sources are being reduced at \$1500 (R9 179, (2000)) per ton greenhouse gases, compared to \$10 000 (R61 194, (2000)) per ton for refineries and \$22 000 (R134 628, (2000)) per ton for all other stationary sources. ¹⁸

The pollution caused by vehicles does not end with air pollution. When a vehicle has served its purpose it has to be scrapped. This causes problems due to the size of a vehicle and insufficient landfills. The US government is therefore also exploring the recycling of as many parts of a vehicle as possible.

Discussion

South Africa is still a developing country. However, first world cities do exist in South Africa with all the problems associated with transport. It will be impossible for South Africa to go as far as the legislation as was done in the US as there are not sufficient resources to enforce such legislation, but it is believed that a no-regrets, no costs approach should be followed. It will be relatively easy to adopt the same vehicle and fuel standards as for the US and Europe. This will also ensure that South Africa is not seen as a dumping

ground for poor quality fuels and vehicles. This initiative could then also be extended to the SADC region.

2.2.2. Europe

The power of US legislation was so strong that it made impacts on other parts of the world. In the US, by 1990 there were 146 million catalyst-equipped vehicles representing 93% of the park while in Western Europe only 7% of the cars were equipped with catalysts which amounted to 10 million vehicles by 1990.

Europe, however, had legislation and inspection and maintenance programmes since the 1960's. The United Nations have been publishing uniform conditions for approval and reciprocal recognition of approval for motor vehicle equipment and parts since 1958, while the European Economic Commission (EEC) has published provisions on measures to be taken against air pollution by positive-ignition engines of motor vehicles since as early as 1968¹⁹. These measures have become more stringent with time. Given the reductions already achieved, further action to reduce vehicle emissions necessitated a reassessment of the existing policy approach since the emission reduction potential offered by further improvements in vehicle technology, was limited and possibly very costly in comparison to other potential solutions. The European Commission, in October 1992 therefore organised a conference with all the relevant interest groups to discuss the issue of vehicle emission standards for the year 2000 and beyond. The major conclusion from this conference was that future emission standards should be based on an integrated approach and should have as their objective the achievement of air quality targets. In this context it was recognised that further steps would be needed not least because of increased traffic activity (increased numbers of vehicles and increased kilometres travelled.)

The new approach was outlined in the legislative proposals the Commission submitted to Council and Parliament in 1992²⁰.

In the proposals (future proposals for emission standards to apply from 2000) the Commission shall take the following approach:

- the measures shall be designed to produce effects to meet the requirements of the Community's air quality criteria and related objectives,
- an assessment of the cost effectiveness of taking each measure shall be undertaken; in this global assessment full account shall be taken, *inter alia*, of the contributions made by:
 - traffic management, (e.g. by spreading the environmental costs appropriately),
 - enhanced urban public transport,
 - new propulsion technologies (e.g. electric propulsion),
 - the use of alternative fuels (e.g. biofuels), could make to improving air quality,
- the measures shall be proportional and reasonable in the light of the intended objectives.

The proposals, aimed at a substantial reduction of pollutant shall comprise in particular the following elements:

- Further improvements:
 - based on the assessment of
 - the potential of the traditional engine and post-combustion technology,
 - possible improvements in the test procedure, e.g. cold-start, starting in low or wintry temperatures, durability (e.g. in the conformity tests), evaporative emissions,
 - measures at the level of type-approval supporting strengthened inspection and maintenance requirements, including, for example, on board diagnostic systems,
 - the possibility of checking the conformity of vehicles in circulation,
 - the potential need for:
 - specific limits for HC and NO_x in addition to a cumulative limit value, and

measures to cover pollutants not yet regulated.

Complementary technical measures include:

- improvements in fuel quality as far as vehicle emissions of dangerous substances (in particular benzene) are concerned,
- strengthening of the requirements of the inspection and maintenance programme

While Directive 94/12/EC was only adopted in 1994, Article 4 of that Directive is the formal expression of the framework within which the Commission carried out its preparatory work for the development of future legislative proposals directed at the reduction of emissions from road transport to be effective from the year 2000.

2.2.2.1. The Auto/Oil Programme

In recognition of the fact that the future Community policy on the control of vehicle emissions should be based on an integrated and comprehensive approach and taking into account the potential of a wide variety of different measures for bringing about cost-effective solutions, the Commission, in 1992, invited the European oil and automobile industries to participate in a collaborative programme with the intention of developing a solid technical foundation upon which the Commission could build its future strategy: this programme subsequently became known as the Auto/Oil Programme.²¹

The Auto/Oil Programme was a groundbreaking initiative in which the resources and expertise of two major industries were combined in collaboration with the services of the Commission and focused on the challenge of developing a rational basis for future legislative action. The programme is an example of the principle of partnership identified in the fifth Environmental Action Programme. In particular the extensive research programme known as the European Programme on Engines Fuels and Emissions (EPEFE) has provided a unique insight into the relationship between engine technology/fuel quality and vehicle emissions.

The rationale of the Auto/Oil Programme was to quantify both the cost and the emission reduction potential of a variety of different measures, which could contribute to reducing vehicle emissions and the attainment of air quality targets. The measures which were included in the analysis included not only advances in vehicles technology and fuel quality but also the benefits of improvements to the regular inspection and maintenance procedures as well as the potential contribution of non-technical measures such as road pricing, improved public transport and scrappage schemes. The objective of the auto/oil analysis was to identify cost-effective packages of measures sufficient to reduce vehicle emissions to the level compatible with the achievement of rigorous air quality standards throughout the European Community.

The critical air quality objectives, which were eventually used as the basis for designing the package of measures to reduce road transport emissions, are presented in the table below.

Table 5 Air quality targets

Pollutant	Urban NO ₂	Urban Carbon monoxide	Urban Benzene	Urban Particulates	Tropospheric Ozone
Air Quality Targets:	200 µg/m ³ As maximum hourly value	10 mg/m ³ As maximum hourly value	10 µg/m ³ As an annual mean	50 µg/m ³ As a 24 hour rolling average	180 µg/m ³ As a one hour 99%ile value.

The Auto/Oil Programme focused exclusively on the control of emissions from the road transport sector. While for the majority of atmospheric pollutants, road transport constitute the single most important source of emissions other sources such as power stations, industry and individual households also make a significant contribution. The implementation of the measures arising out of the Auto/Oil Programme will ensure that emissions from road transport are reduced to a level compatible with the attainment of rigorous air quality standards. However, in order that the air quality standards are achieved it will

require equally significant and parallel reductions in emissions from other man-made sources. In particular the results from the Auto/Oil Programme have demonstrated that reductions of man made emissions of both Volatile Organic Compounds (VOC's) and oxides of nitrogen (NO_x) of the order of 70+% as compared with today's levels will be required if air quality targets for tropospheric (low-level) ozone are to be achieved.

The message, which was to be underlined in relation to the control of vehicle emissions, is the interdependence of all the elements in the systems. The technical components need to be compatible and the administrative systems need to inter-lock and be mutually supportive. In addition vehicle manufacturers and oil companies need to comply with their obligation. Finally and very importantly, individual vehicle owners have a major role to play in reducing vehicle emissions: responsible driving behaviour has a significant effect on fuel consumption and emissions; poorly maintained vehicle contribute a disproportionate amount to the total pollution load from the vehicle fleet.

2.2.2.2. The legislative package arising from the Auto/Oil Programme

Passenger cars

The emission standards for passenger cars will be tightened. A summary of the new emission standards to come into force in 2005 is given in Table 6.

Table 6 Emission Standards for Passenger Cars in grams/km²²

Petrol	As from (2)	CO	HC	NO_x
Euro I	1/7/1992	4.05	0.66	0.49
Euro II	1/1/1996	3.28	0.34	0.25
Euro III	1/1/2000	2.30	0.20	0.15
Euro IV	1/1/2005	1.00	0.10	0.08

Diesel	As from (2)	CO	HC	NO_x	PM
Euro I	1/7/1992	2.88	0.20	0.78	0.14
Euro II	1/1/1996	1.06	0.19	0.73	0.10
Euro III	1/1/2000	0.64	0.06	0.50	0.05
Euro IV	1/1/2005	0.50	0.05	0.25	0.025

Notes:(1) "Euro III and IV" (Directive 98/68/EC): standards also apply to light commercial vehicles (<1305kg).

(2) the above dates refer to the new vehicle types; dates for new vehicles are 1 year later.

Improved Fuel Quality

The Auto/Oil Programme confirmed that improved fuel quality can have a significant impact upon pollutant emissions from vehicles.

Specific reference was made to the need to address the problem of the benzene content of petrol. In the proposal the maximum content of benzene should be reduced from 5% to 2%.

The Commission's proposed fuel quality framework directive also includes a commitment to explore further the potential of CNG, LPG, biofuels and other alternative fuels.

Inspection and Maintenance

In the Commission's proposals there are two sets of emission limits. The first set of emission limits will be obligatory and apply as from the year 2000. The second set of emission limits, which is considerably more ambitious than the first, will come into force in 2005.

2.2.2.3. The costs and potential benefits of measures to reduce pollutant emissions from vehicles

The European Programme on Emissions Fuels and Engine Technologies (EPEFE)

One of the first steps taken in the Auto/Oil Programme was to review all available data concerning the relationships between vehicle emissions fuel properties, and engine technologies: this review included the results of the US Auto/Oil Programme. The conclusions from this review were published in

1994 in the report entitled: 'Effect of Fuel Qualities and Related Vehicle Technologies on European Vehicle Emissions.'

In reviewing existing information on the relationship between fuel quality, engine technology and exhaust gas emissions it became apparent that gaps existed concerning certain fuel and vehicle interactions. As such knowledge was vital for the completion of the Auto/Oil Programme, the European Oil and Vehicle industries collaborated in the realisation of an extensive research initiative designed to generate the missing data. This research programme was known as the 'European Programme on Emissions, Fuels and Engine Technologies (EPEFE)'.

The EPEFE programme was successful and has allowed important insights into the relationships between fuel quality and emissions. These relationships are complex, indeed it was observed that in some cases changing certain fuel parameters would decrease emissions of one pollutant while increasing emissions of another.

It has assisted in the qualification of the relationship between certain important fuel parameters (e.g. sulphur content, aromatics content, distillation characteristics for gasoline, cetane number, density, poly-aromatics content, and distillation characteristics in the case of diesel) and pollutant emissions.

2.2.2.4. Cost effective solutions to achieve air quality targets

The most important step in the Auto/Oil Programme involved the exploitation of the data compiled on the costs and benefits of the various emission reduction measures in order to identify the most cost effective solutions to achieve the emission reduction targets.

In the original concept of the Auto/Oil Programme it was foreseen that emission reduction targets would be generated in a consistent manner for all pollutants and that least-cost solutions would be generated simultaneously in order to satisfy these multiple emission reduction objectives. However, it was

not possible to determine precise emission reduction targets for particulate matter in each of the major cities although a tentative objective of a reduction in the range of 50-65% as compared to present levels was identified. Similarly reduction targets for total NO_x and total VOC's as precursors of regional ozone were difficult to establish: again tentative reduction targets in the range of 70-80% for both pollutants compared to 1990 were identified.

The objective was to identify the most cost-effective series of interlocking measures such that a certain proportion of the background levels of pollution would be removed by EU wide technical measures and that as and where appropriate these technical measures would be supplemented by national and/or local measures in localities with elevated levels of pollution - the objective being to achieve the desired emission reductions at the least cost for the Community as a whole.²³

Discussion

In order for South Africa to be efficient in terms of finances it would not be necessary to undertake cost benefit analysis. It is believed that the European and US programmes could be adjusted to suit the South African climate and conditions. South Africa has international oil refineries and motor manufacturers and it should be relatively simple to amend the production of fuel and vehicles.

2.2.2.5. Other occurrences in Europe

A round-table meeting of European business leaders, scientific experts and government representatives called for higher fuel taxes to curb the rapidly rising CO₂ emissions from the transport sector in 1996. The meeting, held in Copenhagen, Denmark, was organised by the World-Wide Fund for Nature and proposed specific strategies for combating climate change. Three areas for future co-operation were agreed upon:

- better communication to increase public urgency about the climate change problem;

- increased fuel taxes in the transport sector to curb the CO₂ emissions growth;
- joint government and business measures to promote information on energy efficiency.²⁴

In order to reduce CO₂ emissions and as a result of the promotion of LPG, a more positive approach is being shown towards LPG in some parts of Europe and the city of Vienna, Austria continues to use LPG widely in its bus fleet, as it has for over 30 years. Britain also saw LPG ambulances entering service in Oxford as part of a 14 vehicle fleet conversion that was funded by the Department of Environment's Energy Savings.²⁵

Another way to curb air pollution was developed by West German cities, which involves using speed limits to slow down cars on urban streets. A five-year experiment designating thousands of such streets nation-wide as "Tempo 30" or a 30-kilometre-per-hour speed limit. Tempo 30 zones showed significant reductions in accident rates and noise and exhaust levels, with no increase in speeds or accidents on nearby major roads. Following the end of the experiment in 1989 demands for Tempo 30 arose from all over the country.²⁶

Around 42 million tonnes of lubricating oil are consumed every year, world-wide. Of this 22 million tonnes of used lubrication oil are generated and only 10 million to 15 million tonnes are recycled. There are three routes for lubricating oil disposal: dumping, laundering and re-refining. A fourth option is gasification of the material. Dumping should of course be totally unacceptable on environmental grounds, yet dumping of oil in landfills or down drains accounts for a high percentage of used oil disposal - 32% of all used oil generated in the US in 1988. One of the problems is the fragmented approach to used-oil collection - leaving many motorists no option other than to pour away used oil. In Germany, for example, used oil is classified as hazardous waste and the generator pays for collection. In France there is a subsidised collection scheme and in the UK, the collector pays.²⁷

Recycling of lubricating oil can range from 'laundering' - dewatering and filtration- to re-refining, for which various processes have been developed commercially. The acid and clay process used to be the most common but is in decline in environmentally sensitive areas because of the disposal problems associated with the acid sludge produced. Thin film evaporation - essentially dewatering, light ends stripping, vacuum distillation, thin film evaporation and fractionation with mild dehydrogenation to reduce polynuclear aromatics and chlorinated compounds - is becoming more popular and replacing propane precipitation processes. Thermal de-asphalting in a vacuum column is another method of separating base oil from contaminants.

Market acceptability of recycled oils will be a significant determinant in the growth of lubricating oil-recycling plants.

The problem does not end there. Pollution of air and water also occurs when a vehicle is manufactured which is a relatively large-scale industrial activity. Industrial processes used raise a number of environmental concerns. Principle among these are:

- resource (material) consumption;
- water consumption, both industrial and drinking quality;
- energy consumption and energy sources;
- pollution of water, air and land;
- waste generation and disposal, including incineration;
- noise
- transport and congestion.

Table 7 The main Environmental concerns in car manufacturing

	RESOURCES	WATER USE	ENERGY USE	POLLUTION	WASTE	NOISE
PRESSING	Material yield	-	Yes	Lubricants	Yes	Yes
WELDING	-	Cooling	Yes	Gases	-	Yes

	RESOURCES	WATER USE	ENERGY USE	POLLUTION	WASTE	NOISE
CASTING	-	-	Yes	Yes	-	Yes
MACHINING	Material yield	Yes	Yes	Lubricants (+swarf)	Yes	Yes
PAINTING	-	Yes	Yes	VOC's; paint sludge	Yes	-
ASSEMBLY	-	-	Some	-	Packaging	-

In the above table these concerns are compared with the main industrial processes to be found in the average car plant involved in the manufacture of bodies and engines, and the final assembly of complete vehicles. In practice, of course, other activities may be included such as gearbox machining and plastic injection moulding of bumpers.²⁸

Recycling might be the answer to these problems and therefore plans are being made to recycle but problems are also being experienced in this field. The car-recycling scheme in Germany looks set to conflict with the European Union's legislative plans for the sector. The European Commission is known to favour mandatory recycling rules that would require manufacturers to take back used cars and recycle their components. The European Commission argues that only a compulsory scheme will provide a level playing field for manufacturers.²⁹

Sweden

As a result of the air pollution problems experienced in Sweden, the government initiated an investigation into fuel alternatives. The investigators are in favour of alternatives to petrol and diesel, notably fuels derived from renewable resources. The study is the first step in a policy making process with the broad support of the country's environment minister, Anna Lindh, who commented that biofuels 'do much less to harm the climate' and Sweden will play its part in reducing fossil fuel CO₂.³⁰

Research has therefore been done in Sweden and City Diesel has been developed. City diesel has lower sulphur and aromatics content, kerosene-like viscosity, and produces less smoke and other pollutants than ordinary diesel fuel. It has been commercially available in Sweden ³¹ since 1990 and it is now fully established as the environmentally friendly fuel it was designed to be. Treatment with a few parts per million lubricity (anti-wear) additives since mid-1991 has cut initial rotary pump failure problems virtually to zero. Rapid means of forecasting wear performance of treated fuels are now a main concern, and they are being developed.

Other measures to curb pollution and congestion are also being investigated. In Goteborg, for example, the city centre is divided into five pie-shaped zones, all accessible by a large ring road on the periphery. Automobiles may not cross the zone boundaries, but public transport, emergency vehicles, bicycles, and mopeds can. Goteborg's cell system was instituted in 1970 along with reserved lanes for buses and trams, and some streets closed to all but pedestrians. Since then, the city has had fewer accidents and better public transport service. Traffic cells are also found in Bremen, West Germany (where they originated); Besancon, France; the Dutch city of Gronigen; and Tunis. ³²

While many cities have evolved compactly because of clear constraints on space, other with plenty of available land have purposely contained sprawl in the interest of efficiency. Sweden's cities - compact centres surrounded by vast stretches of rural, largely forested land - demonstrate the success of the country's strong urban land use policies. The Soviet Union also makes efficient use of urban space despite its great size. ³³

Netherlands

The Dutch use traffic calming measures to encourage cycling and walking. For more than two decades they have calmed traffic by changing the layout of the residential street, transforming it into a *woonerf*, or 'living yard'. In the *woonerf*, cars are forced to negotiate slowly around carefully-placed trees and

other landscaping. Since motor traffic cannot monopolise the entire breadth of the street, much of the space is made more open to walking, cycling and children's play grounds. Automobiles are free to enter the woonerf, but only as "guests", while non-motorised traffic has priority.³⁴ Experience with traffic calming has shown that it is most effective if widely implemented, so that motor traffic problems are not simply diverted to nearby streets.

The United Kingdom

In the United Kingdom, the general high levels of particulate matter emissions can be ascribed, mainly, to diesel vehicles although the city with the highest levels of particulates, Belfast,³⁵ finds itself in that position because of its continuing high levels of coal burning.

Progress has already been made regarding diesel emissions as London Transport is now running over a quarter of its route in miles on ultra low sulphur city diesel and 250 of the Routemaster double decker buses have also been fitted with oxidation catalysts to further improve exhaust emissions. Tests at Millbrook Proving Ground have shown that the retrofitted vehicles, in typical London operating conditions, saw particulates reduced by around 75%, NOx by 25%, CO by 25% and unburned hydrocarbons by up to 90%,³⁶ as well as a subjective improvement of smell and smoke.

Britain is also looking towards the reduction of traffic in order to curb air pollution. The UK Road Traffic Reduction bill proposes National targets of a 5% reduction in traffic by the year 2005 and 10% by the year 2010.³⁷ Furthermore, a consultation paper has been published on proposed vehicle excise duty (VED) incentives for lorries meeting future emissions standards.

The transport and storage of oil present pollution risks all over the world. The UK government has proposed legislation that would set minimum pollution control standards for new storage installations designed to hold refined oils. A legislative approach is now being pursued because voluntary schemes have

proved ineffective with more than 6000 oil pollution incidents occurring annually.³⁸

France

In France the air pollution problems are so serious that the Lyon authorities has had to ban heavy lorries from the motor way through the city. High levels of NO_x have also led, at-times, to bans on school sports and requests to elderly people not to over-exert themselves.

The Organisation for Economic Co-operation and Development (OECD) has attributed this to France's failure to deal with particulate emissions from its large diesel fleet. Although generally complimentary about the country's environmental policy, particularly with regard to industrial pollution, the OECD notes with concern that poor air quality in urban areas is a common occurrence.³⁹ The report concludes that the devolution of power to the local level has led to too much emphasis on economic interests over environmental concerns.

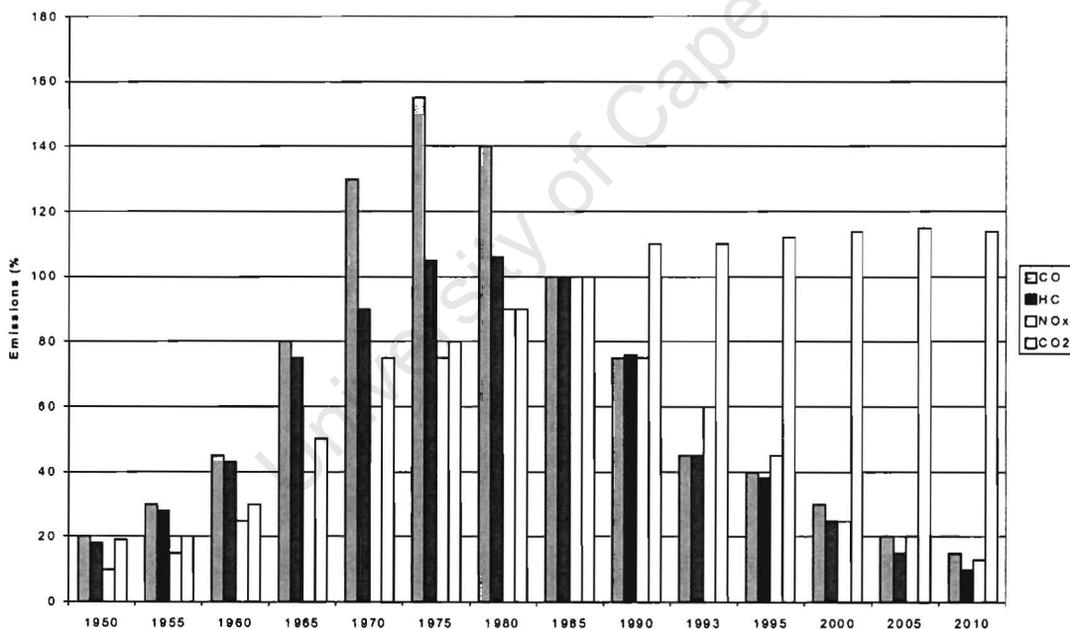
Other countries found public transport to be part of the answer for air pollution problems but although integrated public transport mechanisms are well established air pollution problems remain a concern in France. The Paris region is a good example of a well-integrated system of dense public transport service, with a suburban rail line within three kilometres of almost any point in the metropolitan area. There is a metro line within 600 metres of any point of the city, and the stops are even closer in the centre.⁴⁰ In recent years, several large Western European cities have stepped up their commitment to public transportation, combining further investments with complementary policies to restrict auto use.

The impact of 15 years of emissions legislation in Europe

Since 1985 the Touring Club Schweiz (TCS) has constantly tested the exhaust emissions and fuel consumption of more than 300 new cars fitted with catalytic converters (31 different makes). In parallel, the efficiency and

service life of the catalyst and surrounding components were monitored by long-term tests on 26 cars over a kilometre count of up to 250 000 km. All the measurements were based on the driving cycles FTP 75 and HDC and, since 1996, on the European test cycle. In addition, independently of any changes in the legal regulations, the emission data were also recorded at constant speeds of 100, 115 and 130km/h. The results of the measurements clearly indicate car manufacturers' efforts to reduce exhaust emissions and fuel consumption. Relative to the base year of 1985, emissions in the TCS cycle at constant speeds have been reduced by 55% in the case of carbon monoxide, 15% in that of hydrocarbons and 73% in that of nitrogen monoxide⁴¹.

Figure 1 Emissions from cars in Europe (reference year 1985) taking into account the introduction of Euro III and Euro IV



Since the introduction of the catalytic converter in 1985, the volumes of toxic substances emitted in Europe (Switzerland) have been considerably reduced. This does not, however, close the subject of exhaust emission control. Major efforts on the part of manufacturers are also necessary in the future, as legislative standards continue to rise constantly. Legal targets alone are not enough, however. An independent inspection is still imperative in order to

raise the awareness of this subject among both manufacturers and the general public and consumers, and to ensure low exhaust emissions throughout the life span of a vehicle.

Discussion

It will be impossible for South Africa to get inspection and maintenance programmes going for all vehicles, but it is believed that these programmes could be introduced at a very low cost for government vehicles, local authority buses and heavy freight trucks. This would also have a positive impact on accident rates and the creation of dangerous situations by break-downs on the side of the roads.

2.2.3. Soviet Union

The true scale of urban air pollution in Russia was described by the State Environment Committee chairman who revealed that 200 Russian cities experience pollution levels much higher than permitted and 120 of those exceed government standards by a factor of 5.⁴² As a result 40% of Russia's population live in areas with dangerous levels of air pollution. Industrial activity and vehicle emissions share the blame for the problems.

These air pollution problems persist although cities in the Soviet Union and Eastern Europe provide extensive and comprehensive public transport options, including buses, tramways, metros, and suburban trains. Although quality varies along with public spending constraints - from showpiece metros in the largest cities to undependable, overcrowded systems elsewhere - the various transport modes offer widespread service to many people who do not own cars.⁴³ Of the roughly 300 streetcar and trolley systems in the world, about 110 are in the Soviet Union and another 70 are in Eastern Europe.

2.2.4. Asia

Many of the vehicles used in Asia are among the most polluting in the world, especially with regard to sulphur in diesel fuel and lead in petrol, and in some

Asian countries today, it is not yet possible to purchase unleaded petrol. As a result of the large and growing population of poorly maintained vehicles with minimal, if any, pollution controls, powered by dirty fuels,⁴⁴ most major cities of Asia are already experiencing serious motor vehicle related air pollution, frequently on top of other serious environmental problems.

A major factor contributing to the quantity of vehicle emissions in urban areas is the fuel economy of vehicles. There is considerable scope for improved fuel economy in certain parts of the region. The typical domestically manufactured car in India and China (17-20mpg) are half as fuel efficient as "best practice" in OECD countries (42mpg).⁴⁵ Fuel economy standards, differential vehicle taxes and 'bonuses' for scrapping less fuel-efficient vehicles are some of the measures, which could be adopted to promote greater fuel efficiency.

Another way to ensure greater fuel efficiency would be land use controls. These, however, have had relatively little success in developing countries because of rapid growth, lax enforcement, and inability to meet regulations, along with other obstacles. Particularly in Asian cities, high densities already overwhelm the public transport systems. Yet since so few people have automobiles, it is important for urban distances to be on a walking or cycling scale. Hong Kong, Seoul, and Singapore have helped manage travel demand by drawing development into designated sub-centres outside their cores.⁴⁶ Singapore's plan used an extensive low-income housing program to place jobs and homes within short distances, partially relieving downtown congestion without expanding the transport system.

Public transport, therefore, plays an important role in urban areas of the Third World. In many cities in Asia, Latin America, and Africa, buses - in their various forms - make up 50 to 80% of all motorised trips. Buses are sometimes overcrowded; it is not uncommon to see of riders clinging to the sides of the vehicles.⁴⁷ Yet most Third World cities have less public transport ridership per person than those in Western Europe, reflecting the inability of bus fleets to keep up with population growth.

As a result of the increase in the use of buses and private vehicles traffic noise is becoming an increasingly worrying irritant in most cities in Asia. Little data exist on noise levels but buses and trucks are major culprits, as is evidenced by data from Bangkok (one of the few cities where noise measurements have been undertaken.)⁴⁸ Data collected alongside densely travelled roads in Bangkok revealed daily noise levels between 75 decibels (dB) and 80 dB, much higher than the 70 dB standard recommended by the United States Environmental Protection Agency (USEPA) for long term hearing protection.

2.2.4.1. Thailand

In Thailand the Office of the National Environment Board has monitored levels of carbon monoxide, particulate matter and lead near major roads in Bangkok since 1984.⁴⁹ According to their annual report, in certain areas of the city where traffic is high, particulate matter concentrations far exceed the daily ambient air quality standards of 330 microgram/cubic meter per day, and are as high as 2-3 times standard values on some days.

A study of blood-lead levels of policemen in Bangkok who had been subjected to three different rates of exposure to vehicular traffic, found a statistically significant link between traffic exposure and blood-lead levels.⁵⁰

2.2.4.2. Singapore

In order to curb pollution and health problems and to enhance economic productivity Singapore has demonstrated that the combined effects of restraining motorisation, restricting vehicle use and providing efficient, affordable and attractive public transport services can avoid congestion; and toll expressways are being introduced in Indonesia and Thailand as differentially priced alternatives for the motorist to the congested road network.⁵¹

2.2.4.3. *China*

In much of the developing world, more car buying only means that a small elite is improving its travel options, while the vast majority's mobility and accessibility are impaired. People in Third World cities have to live with air pollution, congestion, and dangerous streets - yet most will never enjoy the privileges of an automobile.⁵²

The poor majority must make use of public transport and it accounts for three-quarters of all journeys in Hong Kong. About one-third of these are by light buses and taxis, nearly all of which are diesel powered. Control of emissions from poorly tuned diesel vehicles represents the most important transport environmental problem in the territory. Road traffic contributes between approximately 45% and 75% of the territory's fine particles and nitrogen dioxide levels, with the overwhelming share of these being from diesels. The diesel emissions problem is even more serious than these figures suggest. Light buses and taxis comprise much of the traffic in the narrow streets of high-density residential and commercial areas where residents, office workers and pedestrians are directly exposed to relatively high concentrations of air pollutants during peak traffic hours.⁵³

Chengdu, the capital of Sichuan province, has become the latest Chinese city to show progress with attempts to reduce emissions from traffic. The local authorities have introduced legislation that will involve testing a vehicle's emissions with those that fail being required to install pollution control devices.⁵⁴

Transport pollution in Hong Kong involves an interesting variation on the tendency of regulators and economists to use rather different criteria in evaluating possible control measures. In Hong Kong, as in many other parts of Asia, diesel powered buses account for a large proportion of transport journeys. While diesel vehicle engines can be relatively clean, in practice they are often poorly tuned, leading to high outputs of particulates, nitrous oxides and other pollutants.

The major near- and medium-term options considered in Hong Kong for reducing diesel road transport air pollution were:

- switching new light buses and taxis to gasoline fuelled engines with catalytic converters, through either mandates or strong financial incentives;
- stringent performance standards for new diesels and enforcing better maintenance on existing ones through a programme of frequent (three to four per year) emissions standards and inspections; and
- waiting for improved diesel emission technology (e.g. reliable particulate traps, less maintenance intensive emissions reduction technology.)⁵⁵

In preparation for the switch of light buses and taxis to gasoline and catalytic converters, unleaded gasoline was introduced into Hong Kong in 1991 and beginning in January 1992, all new gasoline fuelled vehicles were required to have catalytic converters. These moves in themselves had rather small environmental benefits to Hong Kong, since nearly all existing gasoline fuelled vehicles are private, and such vehicles play a relatively minor role in Hong Kong's transport picture. However, these were seen as necessary steps for the planned gradual shifting of lighter public transport (and light goods vehicles) from diesel fuel to a cleaner alternative fuel system.⁵⁶

Non-motorised travel is also encouraged as part of the planned gradual shift to environmentally friendly modes of transport. Chinese cities, therefore, provide exclusive pedestrian/cyclist lanes and bridges for the country's 300 million cyclists, and various turning restrictions on motor traffic at dangerous junctions.⁵⁷ Some city governments in China have relieved pressure on overcrowded buses by paying commuters a monthly allowance for cycling to work.⁵⁸

2.2.4.4. Japan

Until the last few years, and with the exception of lead reduction in gasoline, legislation designed to reduce pollution from vehicle emissions in Japan was focused on what was achievable from vehicle design changes, proper operation and maintenance, and use of catalytic converters and carbon canisters, and not on changes to fuel specifications. Legislation, therefore, tended to affect vehicle manufacturers more than oil refiners.⁵⁹

Direct injection petrol technology developed by both Toyota and Mitsubishi has led to the Paul Piertsch award for automobile technique and design from German motor magazine Auto, Motor and Sport in 1997. This is the first time that a Japanese company has received a European technology award. A Toyota representative who received the award on behalf of the company said that although the technology requires further work, 'it has the potential to become the engine of the 21st century'.⁶⁰

Creative measures to reduce air pollution are being implemented in Osaka. Tests are run with paving stones that remove NOx from the surrounding air which have been developed by Mitsubishi Materials Corporation at a cost of 65 yen (R3.78, (2000)) per square metre.⁶¹

Japan is one of the leading countries when it comes to electric vehicles. Two major Japanese automakers are introducing electric vehicles powered with advanced battery technologies. Nissan is currently marketing its Prairie Joy EV, a four seat sport utility/station wagon, to commercial and government fleets in Japan. The battery used is a lithium -ion battery with a range of 125 miles (201.12km) in city traffic.⁶²

Other methods to curb air pollution and congestion in Japan have failed, the Tokyo authorities are to get tough on the car-dominated Japanese capital. Various voluntary measures, have been tried recently - requests for reduced fleet deliveries, company 'walk home' campaigns, and discounted public transport tickets have all been promoted but with little impact. Mandatory

park-and-ride schemes are now being considered along with a system to restrict vehicle circulation by licensing plate numbers similar to that used in Mexico City.⁶³ The system used in Mexico City implies that on certain days of the week only cars with certain registration numbers will be allowed into the city. (This has, however, resulted in people having more than one car to use alternatively.)

The land use problems in Japan are increasing. Once all available surface space has been surrendered to private cars, engineers turn to space overhead and underground. Entrepreneurs in Yokohama, Japan, recently opened a floating parking lot in the local bay.⁶⁴

Japan is also investigating innovative ways to conserve scarce resources like oil. Mitsubishi Heavy Industries Ltd began experiments to transform waste plastics into fuel oil for diesel engines.⁶⁵

2.2.5. Developing countries in general

Much faster growth is occurring in the developing countries, which are avidly chasing the dream of car ownership. Although international debt and severe economic troubles have checked auto expansion in developing countries, their fleets are still growing twice as fast as those in industrial countries.⁶⁶

Preventing transportation crises, as a result of this growth, in the 21st century requires a full commitment to public transport. Particularly in the dense centres of the developing world, as exponential growth continues and environmental constraints tighten, the need for alternative systems that can move the greatest number of people using the least space and fuel will become even more acute.⁶⁷

The growth in vehicle demand results in increasing fatalities. Developing countries' fatality rates from road accidents are 20 times those in the industrial world; a study of 15 developing countries found that road accidents were second only to intestinal diseases as the leading cause of death.⁶⁸

Non-motorised travel could be the answer to the above mentioned problems. Alternatively motorcycles and mopeds are increasingly popular in most of the populations of the developing world, but in addition to being heavily polluting, they are too costly for those with low incomes and require expensive, scarce fossil fuels. Even buses are out of reach for many; it is estimated that one-fourth of households in Third World cities cannot afford public transport. For those who can, it typically requires 10 to 15% of their income.⁶⁹

Third world countries face different transportation problems, as these countries generally are poor and cannot afford expensive solutions e.g. light rail systems. However, if the true costs of private cars, motorcycles and mopeds are taken into account the light rail solution might not be as far fetched as initially anticipated.

2.2.6. Mexico

The Metropolitan Area of Mexico City lies on the south-eastern part of the Mexico basin at an altitude of 2240m above sea level. The basin is surrounded by mountains, with a pattern of winds blowing from the north west and the north east. The geographical situation of the basin, its meteorological characteristics, and the emission of air pollutants combine to make it a great natural reservoir in which complex photochemical reactions produce oxidant chemical compounds. This situation in Mexico is not unlike the situation experienced in Cape Town. The presence of ozone as an atmospheric pollutant in Mexico City was noticed as long ago as 1958.⁷⁰

Uncontrolled automobile exhaust emissions are important sources of air pollution. The polluting emissions of almost 2.5 million vehicles in the Mexico City Metropolitan Zone are estimated to be approximately 11 000 tons a day, composed of particles (0.3%), carbon monoxide (89%), oxides of sulphur (0.3%), oxides of Nitrogen (0.9%), and hydrocarbons (9%).

Despite the fact that nitrogen oxides and hydrocarbons constitute little more than 10% of these emissions, their importance in the generation of photochemical air pollution makes them potentially the most serious problem for air quality in the Mexico City Metropolitan Zone at the present time. Ozone is produced when sunlight triggers the formation of nitrogen oxides. Levels are highest during the day, usually after heavy morning traffic has released large amounts of the precursor pollutants. As a result of wind transport of the mass pollutants containing ozone precursors emitted in the northern and central parts of the City, the maximum concentrations appear downwind of the emission zones, towards the southern part of the urban area.

On the other hand, the use of heavy bunker oil and diesel oil with a relatively high sulphur content (3.5% weight) in most of the industrial plants, including two power plants, is responsible for the main sulphur dioxide emissions and consequently the higher levels sulphur dioxide on the North of the Mexico City Metropolitan Zone, where the industrial zone is located.

Measurements of precursors, ozone and sulphur dioxide have been made since 1980 at the Centro de Ciencias de la Atmosfera (University Station), located on the southern area of Mexico City where the maximum ozone concentrations of the whole Metropolitan Zone are currently recorded. Lead content analysis in total suspended particles are routinely made by the office of the Under Secretary of Ecology.

The ozone data at the University station show that the ozone levels before September 1986 exceeded the air quality standard for ozone of 0.11 parts per million (ppm) (maximum hourly average) on just a few days since 1980.⁷¹ The ozone situation has worsened since September 1986, coinciding with the introduction by Petroleos Mexicanos of a new formulation in the regular gasoline (NOVA-PLUS), looking for a reduction of the high lead concentrations previously observed in suspended particles.⁷²

The NOVA-PLUS gasoline was formulated with refinery reformatting gasoline with high levels of olefins, alkyl and aromatic blends and with a low content of tetraethyl lead, resulting in a high octane gasoline.

The reduction in the lead content worked as expected. However, the side effect of the use of the new gasoline in a fleet without catalytic converters was a significant increase in ozone formation. The nitrogen oxides increased because of the new high temperature in the combustion of the NOVA-PLUS gasoline, and the balance in the reactive organic gases emitted by the mobile sources changed to a high percentage of very reactive organic compounds.

The ozone effects in the ecosystem of the Mexico Basin are notorious. The phytopathological damage due to ozone is already present in the woods and vegetation of the southern zone of Mexico City.⁷³ Further effects are to be expected not only on vegetation, but also on the health of Mexico City's inhabitants as they are exposed to ozone levels considerably in excess of those of previous years.

From the above discussion it is clear that very reactive organic compounds and nitrogen oxides in excess are emitted by cars without control emissions as a consequence of using reformatting gasoline rich in olefinic and alkyl-aromatic compounds.⁷⁴ The direct effect of the presence of these precursors in the atmosphere of the Metropolitan Area of Mexico City is the formation of high levels of ozone.

In a further effort to relieve the air pollution up to 1000 taxis in Mexico were converted to natural gas. Faced with some of the worst air quality in the world, city authorities have been experimenting with different alternative fuels over the past three years and have reached an agreement with public transport entities to introduce the LNG as fuel. Tests by the Mexican Natural Gas Association (MNGA) showed that natural gas vehicle (NGV) taxis emit 96% less pollution than conventional vehicles, many of which are powered by leaded petrol.⁷⁵

In order to decrease the air pollution problems over the past two decades, large cities, including Mexico City, have built metro systems. These projects have greatly improved transport service in dense city centres but at great financial cost, raising widespread doubts about their economic viability in developing countries. But in areas with high densities, where even expanded bus service cannot cope with the demand for transport, new metros are being planned despite their high cost.⁷⁶

2.2.7. Australia

Australia has a very high per capita rate of motor vehicle ownership. So, despite a very low average population density, air pollution values can reach relatively high levels by international standards, particularly in the largest cities.

Australia's two largest cities, Sydney and Melbourne, exceed 0.12 ppm ozone one hour average on several days a year and other cities have the potential to produce this level without some control.

The various States and Territories are responsible for the control of air pollution from stationary sources. However, the Federal Government has, since 1976, set design rules governing all new motor vehicles intended for sale in Australia to ensure uniform minimum control standards throughout the nation. In 1989, the Federal Government formally took over responsibility from the States for setting motor vehicle emission standards although the States are currently still responsible for their enforcement.

The Environmental Offences and Penalties Act of 1989 which was updated in late 1990, provides for three levels of penalties of which tier 3 accounts for on the spot crimes with fines in the range of \$150-\$160 (R917-R979, (2000)) for noisy vehicle exhausts and polluters.

The design of vehicles to meet air pollution standards is controlled under the Australian Design Rule System administered by the Federal Department of

Transport. Australian Design Rules are agreed by the Australian Transport Advisory Council and attain legislative standing by being included in the Road Traffic Acts of the various States. Australian Design Rules for pollution are prepared by a joint advisory committee of the Australian Transport Advisory Council and the Australian and New Zealand Environment Council.

Since 1986, all new motor cars in Australia have to run on 91-93 RON petrol and meet 0.93 g/km for hydrocarbons, 9.3 g/km for carbon monoxide and 1.93 g/km for oxides of nitrogen.

From January 1988, all passenger vehicles below 2.7 ton gross vehicle mass were required to meet the standards.⁷⁷ In-service smoke control is implemented in some States.

Cities in Australia are also beginning to rethink their inefficient use of land. Some cities decided to use some federal road building funds to build a light rail system instead, and worked out plans to intensify development along the rail corridor. These cities intend to use revenues from joint development projects (such as leasing air rights over stations to private developers) to make the light rail line self-sufficient. The encouragement of multi-family housing in low-density areas, and emphasising housing in the city centre forms part of the strategy. City officials also are restricting downtown parking and giving traffic priority to both the light rail and some bus routes.⁷⁸

2.3. Alternative sources of energy investigated in other countries

2.3.1. Electric vehicles

With the ability to operate almost silently in urban areas without producing any local toxic emission, battery electric vehicles (EV's) are one of the most environmentally friendly vehicles available with current technology. That is provided that there are no, or very low, emissions from the power plant producing the electricity in the first instance. It is, however, easier to contain emissions from a power plant outside a city than to contain emissions from an

urban area. The emissions outside of an urban area also do not affect that many people as within an urban residential area.

Electric cars fall into three categories: those powered solely by batteries which are charged from stationary power sources via the mains electricity supply; those whose batteries are charged from an on-board generating machine, with or without the ability also to be charged from an external source, and trolley buses.

2.3.1.1. Battery Electric Vehicles

Battery electric vehicles have been in use since the dawn of the age of the motor vehicle but have made little progress other than in some niche applications, where silence of operation and stop/start deliveries outweigh the penalty of greatly increased vehicle mass. Examples are the thousands of electric milk floats that have operated in the UK for the last 60 years. These vehicles have suffered from severely restricted range on each charge but this is acceptable in these applications where overnight charging of the lead-acid batteries is possible. Battery electric vehicles do not have any local emissions and hence have the ability to qualify as zero emission vehicles (ZEV's) for urban operation. It must not be forgotten, however, that there can be a significant level of remote pollution at the power station, unless the electricity is generated from renewable sources such as hydroelectric or nuclear power plants.

The interest that has recently been generated in ZEV's has spurred intensive development of all aspects of battery electric vehicles. These developments fall into the following categories.

- battery technology;
- drive-train developments;
- fast charging systems;
- electricity supply infrastructure;
- weight reduction;

- reduced aerodynamic drag;
- reduced rolling resistance;
- super-capacitors.

The most intensive development of batteries is taking place to achieve improvements in:

- power density;
- energy density;
- rapid charging with thermal management;
- longer life with more charging cycles;
- lower weight;
- lower cost;

Types of batteries in service use in electric vehicles currently are lead/acid and nickel/cadmium, while those under development include zinc/air, sodium/nickel chloride, nickel/metal hydride, and lithium ion. Lithium ion batteries offer up to 250 miles (400km) on a charge with the promise ⁷⁹ of three times the power density of lead/acid but at very high cost; a battery cost of US\$12 000 (R73 432, (2000)) for 50kWh at 300 V DC and a life of 3-5 years has been quoted. Lithium ion batteries are the subject of intensive development, not only under the US Advanced Battery Consortium, but also in Japan in a programme funded at ¥14 billion (R814 million, (2000)) over 10 years. Sodium/nickel chloride batteries have demonstrated a power density of four times that of lead/acid in an extended trial over 100 000km and 1 000 charging and discharging cycles. This trial continues with the same battery pack.

Although a variety of types of motors and motor controllers have been discussed, a major preference is emerging for brushless DC Motors with AC controllers. In large quantities the cost of such a driveline has been quoted as US\$1 500 - US\$2 000 (R9 179-R12 238, (2000)) for the motor and drive, depending on features. Such a system would be of low mass and give a high performance at reasonable cost.

A major problem that must be overcome before battery electric vehicles can be widely used is that of cost, not only of the batteries and the vehicles themselves, but also of the infrastructure necessary to support them. While the electrical power required to charge a single battery electric vehicle is not large, the requirements of a large fleet, which may all need recharging simultaneously, could overload the existing power supply and require additional local feeders to be provided by the electric power utility companies.

2.3.1.2. Hybrid Electric Cars

The battery electric car, while producing zero local emissions, suffers from shortcomings in terms of severely restricted range and performance, as well as dependency on a potentially expensive infrastructure to provide charging facilities always within range. These limitations stem from the low energy and power density of even the most advanced storage battery compared to the energy density of liquid or gaseous fuels. A hybrid electric vehicle has an internal combustion engine which is capable of driving the vehicle in a low emission mode and also charging the batteries, and an electric motor which can drive the vehicle in a zero emission mode. In effect it is an electric vehicle with an on-board generator plus a relatively small battery pack to provide a limited zero emission range. The ability to charge the batteries from an external source is retained to provide the minimum overall emissions, but the vehicle is capable of operating independently of any external electric supply if necessary. The performance and total range can be similar to a conventional vehicle, while the special features, to be considered later, can lead to high energy efficiency and low fuel consumption.

There are two basic types of hybrid electric vehicles, series hybrids and parallel hybrids, as well as many variations on these two basic principles.

The series hybrid has an IC engine driving an electric generator, which charges the batteries and powers an electric motor in the low emission mode. The electric motor draws power from the batteries and drives the vehicle in zero emission mode. In the low emission mode the electric motor can draw

power from both the batteries and from the IC engine when increased performance is required.

The parallel hybrid has an IC engine, which can both drive the vehicle mechanically and/or drive a motor/generator to charge the batteries. The motor/generator, acting as a motor, draws power from the batteries to drive the vehicle in zero emission mode. When increased performance is required outside the zero emission mode the motor/generator can assist the IC engine.

2.3.1.3. Series hybrids

The series hybrid has an electric transmission, rather than a mechanical system as in conventional vehicles. The IC engine, which may be of any type and run on any suitable fuel, is directly coupled to a generator which provides power for the electric motor driving the wheels. Between the generator and the motor a controller manages the power split to charge the batteries or to provide extra power to the motor from the battery for acceleration, hill climbing etc.

The IC engine can be directly coupled to the generator without clutches or gearing, since the IC engine can run in its optimum speed range or even at a single speed, optimised for maximum efficiency and minimum emissions with the generator designed for that speed. This keeps the IC engine simple, and very low emissions can be achieved. The IC engine only cuts in automatically if the battery is no longer capable of meeting the energy requirements or if its charge falls below a level determined by the controller. No clutches or gearboxes are required as the controller manages the current flow in accordance with the driver's input via a normal accelerator pedal. The wheels may be driven by a single electric motor via a conventional axle or driveshafts, or by wheel motors mounted in the wheel hubs. The batteries are charged from the generator via the controller, which also acts as a battery charger when connected to an external supply. Thus no external charger is required.

The primary disadvantage of the series hybrid system in most cases is that there are extra inefficiencies included in converting the mechanical power output from the IC engine into electrical power and then back into mechanical power. However, the increased flexibility of this system can offer more optimised components that overcome this disadvantage.

One notable series hybrid EV is the Volvo ECC (environmental concept car) which was first demonstrated in 1992. This vehicle, based on a normal saloon car platform, is powered by a 41kW gas turbine running on diesel fuel which drives a directly connected high speed generator capable of running at up to 90 000rpm. Electrical power is fed via an inverter/rectifier unit to either the batteries or the drive motor, or both, as directed by the vehicle management unit (VMU) in response to the driver's commands and the state of the battery charge. If more performance is required than is available from the gas turbine, the VMU causes additional power to be supplied from the batteries up to the maximum 70kW rating of the drive motor. This concept vehicle also demonstrated light weight, due to an aluminium body, with low rolling resistance tyres and a low Cd of 0.23 resulting in a maximum speed of 175km/h and a range on batteries only of about 85km in urban driving. The range under gas turbine operation is around 650km at 90km/h on main roads. Fuel consumption with the gas turbine in operation is 6 litres/100km in city driving and 5.2 litres/100km on main roads, while emissions were measured as 0.11 g/km NO_x, 0.08 g/km CO and 0.006g/km HC. These emission figures are less than one-sixth of the EC Stage 2 limits.

2.3.1.4. Parallel hybrids

The parallel hybrid employs an IC engine to drive the vehicle through a mechanical transmission and also to drive a generator, which charges the batteries. An electric motor, supplied from the batteries, provides the drive in ZEV mode and may also be arranged to assist the IC engine when extra power is called for for acceleration, hill climbing etc. Alternatively the electric motor could drive a different axle. The electric motor may be combined with the generator in one electrical machine as a motor/generator, which also acts

as a starter motor for the IC engine. The parallel hybrid requires a form of transmission which may be automatic or manual, although an automatic system is likely to be preferred, and if driving into a common axle a gear and clutch system is needed that will split and combine the mechanical power as required for the various operating modes.

The main advantages of the parallel hybrid over the series is that the power from the engine is used directly by the drivetrain with no alternator or inverter losses. However, because the IC engine is directly coupled to the wheels, the IC speed is determined by the vehicle speed and the transmission ratio. This direct coupling limits the flexibility of the hybrid control strategy design and, unless a novel clutched transmission is used, requires the engine to idle when the vehicle is at rest. However, the use of an advanced continuously variable, or infinitely variable, transmission could overcome this disadvantage. A parallel hybrid has an efficiency advantage when the vehicle spends the majority of its driving time at a substantial cruise, but a vehicle that operates for the major part of its time in urban operation will lose this transmission efficiency gain due to inefficiencies in the IC engine.

An example of a parallel hybrid layout applied to an existing conventional vehicle platform is shown by that chosen by Mercedes-Benz for a prototype hybrid version of the C-class car, model W202, to avoid extensive modification to the driveline. It was found possible to integrate the 12kW electric motor/generator (three-phase asynchronous type) into the gearbox housing between clutch and gearbox of the conventional driveline and use a 55kW diesel engine in place of the normal 71kW unit. The electric motor/generator has almost the same dimensions as the clutch, so it could be placed in the gearbox housing at the normal clutch position with the clutch repositioned between the diesel engine and the electric motor. The rotor was fixed directly to the input shaft of the 5-speed manual transmission and a revised clutch operating system was fitted to hold the clutch open when in zero emission mode.

2.3.1.5. Fuel Cell Cars

The prospect of a car with an electric driveline powered by fuel cells looks an attractive one. Fuel cells give promise of a high primary fuel efficiency of up to 50%, coupled with extremely low emissions.⁸⁰ However, it is likely to be a long-term potential for cars, although fuel cell-powered buses and vans are running on test and on trials. A major research programme towards the development of the fuel cell car is taking place in the US under the 'Partnership for the Next Generation of Vehicles' (PNGV) between the US federal government and Chrysler, Ford and General Motors with the aim of producing prototypes of family-size cars with up to three times the fuel economy of current vehicles. In this programme one of the three propulsion candidates chosen as being likely to achieve this goal by 2005 is the proton exchange membrane fuel cell (PEMFC).

The advantages of a fuel cell are its efficiency, emissions, range and the absence of moving parts.⁸¹ Fuel cells efficiently convert the energy of a fuel into electric current, which is in turn used to drive an efficient electric motor. In this manner, the fuel cell enjoys clear energy advantages over internal combustion engines and battery vehicles, both in terms of the vehicle itself and the entire energy chain extending from primary energy source to the final vehicle propulsion.

The electrochemical conversion of hydrogen produces only water. And that means absolutely no emissions of carbon dioxide, nitrogen oxides or any other pollutant. A hydrogen-driven fuel cell vehicle really is a "Zero Emission Vehicle".

The range of a fuel cell vehicle is determined solely by the tank size. It is not related to the power rating of the fuel cells. As far as range is concerned, methanol compares favourably with gasoline and diesel in terms of space requirements and weight. Even in the case of hydrogen, which is more difficult to store, the range is still clearly greater than that of a battery vehicle.

When methanol etc. is used there is pollution due to the final Fuel-to-Hydrogen conversion.

Researchers and developers within the Daimler-Benz group, are currently working on a wide range of fuel cell technologies⁸² including:

- Molten Carbonate Fuel Cells for stationary electricity generation
- Solid Oxide Fuel Cells for utilisation at high temperatures.
- Proton Exchange Membrane Fuel Cells, which are favoured, especially for the automobile, because of their working temperature of 20 to 100 degrees centigrade (°C) and their high power densities.

For fuel cell systems to reach their potential, development will have to be carried out in the following areas:

- reduction in cost, size and weight;
- on-board fuel storage, processing and handling;
- integration of the fuel cell, energy store, electric drive and controls into a cohesive system.⁸³

2.3.2. Oxygenated fuels

Oxygenated fuels (oxyfuels) used to lower winter carbon monoxide emissions were pioneered in the State of Colorado and led to the US Clean Air Act 1990 requiring the use of oxygenated fuels in all areas which had not attained the federal air quality standard for carbon monoxide. Oxygenated fuels with an oxygen content not less than 2.7% must be used during those times of the year that are considered 'high carbon monoxide conditions'. In the US, Albuquerque, Denver, Las Vegas, Phoenix, Reno and Tucson are among those cities in which oxygenated fuels have been introduced during the winter months in an attempt to improve combustion efficiency and to reduce carbon monoxide emissions by as much as 20%. In 1995 oxygenated fuels cost about 10-15 cent per gallon (S.A. 45-68 cent per litre) more than conventional fuel.

Oxygenated fuels contain small amounts of ethanol or methanol derivatives. These include ethyl-*t*-butyl ether (ETBE) derived from ether (and produced from corn) and methyl-*t*-butyl ether (MTBE) derived from methanol. The oxygen-rich additives help the fuel's hydrocarbons to burn more efficiently at low temperatures, thereby converting more of the carbon monoxide to carbon dioxide and also reducing hydrocarbon emissions. Nitrogen oxides are unaffected. The minimum 2.7% oxygen by weight in US oxyfuels is achieved by adding 15% by volume of MTBE or 7.7% by volume of ethanol.

In those US cities where oxygenated fuels were introduced, carbon monoxide levels fell by 10-15% (e.g. Denver claims a 12% reduction). They benefit cars with catalytic converters (as well as older cars without) because the catalysts take several minutes to reach their operating efficiency, during which time carbon monoxide and emissions are uncontrolled. If the additives burn incompletely, they can form aldehydes. MTBE and methanol produce very small amounts of formaldehyde, whereas ETBE and ethanol produce acetaldehyde, both of which may cause cancer. A causal link between some people who suffer headaches, insomnia, nausea, dizziness, skin problems and coughs when driving cars using oxygenated fuels is claimed, but not yet confirmed or rejected.

In Finland, oxygenated fuels were introduced in 1991 and now account for 95% of all fuel sold in the country. To achieve an oxygen content of 2%, Finland uses 11% of MTBE or *t*-amyl methyl ether, the latter being favoured. Finland is the only European country to manufacture oxyfuels, which are exported to Sweden for use in their cold winters. Emissions of carbon monoxide in Finland have fallen by 10-20% and hydrocarbons by 5-10% as a result of introducing oxygenated fuels.⁸⁴ The European Union may consider the wider adoption of oxygenated fuels as one way to reduce the benzene content of fuel as oxyfuels, by helping hydrocarbons to burn more efficiently, offer an alternative means of maintaining a high octane content.⁸⁵

2.3.2.1. Other Reformulated (Cleaner burning) Fuels

Reformulating the composition of petrol and diesel that can be used in all vehicles can reduce vehicle emissions and improve air quality. Lowering the volatility of fuel so that it does not evaporate as readily can reduce emissions of VOC's which react with nitrogen oxides in sunlight to produce ozone. Following the worst period of ozone pollution in the US in 1988, national regulations lowered the national average summer Reid Vapour Pressure of petrol, which is a measure of its volatility, by 11%. A further reduction of 3% took place between 1989 and 1990. A modelling analysis of New York City conditions estimated that the impact of the Reid Vapour pressure reductions was a 25% reduction in VOC emissions. The UK Government had intended to reduce the volatility of petrol sold during the summer months by 1993, but was delayed until 1995 due to resistance from the oil industry.⁸⁶ However, lowering the volatility of petrol through a reduction in its butane content may give rise to other pollution problems if the octane level lost through this process is regained by increasing the aromatic content (i.e. giving rise to more benzene) or by the use of oxygenates (i.e. perhaps increasing formaldehyde depending on the additive used.)⁸⁷

Reformulated fuels can lead to small but significant improvements in air quality in an urban area. One of its attractions for air quality managers is that it can reduce emissions from all vehicles, irrespective of age. It can be used all year round, tackling summer air quality problems (e.g. reducing carbon monoxide by its increased oxygen content). There is no need to modify existing vehicles to be able to use reformulated petrol or diesel. It should not affect a vehicle's performance unless the vehicle is in a poor mechanical condition, when drivers may notice a slight increase in fuel consumption and hesitations after start-up. Unlike alternative fuels (e.g. methanol), air quality improvements do not have to wait for several years until the sales of new vehicles designed specifically to use alternative fuels have begun to replace existing vehicles in significant numbers. There is no need to convert storage tanks, service station pumps or workshop equipment as when using alternative fuels. Given their higher costs of manufacturing and retail price,

reformulated fuels can be used selectively if necessary - that is, in a city with poor air quality rather than throughout the country.⁸⁸

2.3.3. Alternative fuels: Biofuels

Biofuels have received increasing attention in recent years as a possible replacement for petrol or diesel or to be mixed with conventional fuels. Biofuels may be alcohols such as ethanol and methanol to replace petrol or esters such as rapeseed methyl ester to replace diesel.⁸⁹ As ethanol and methanol are liquids they offer a potentially convenient replacement for petrol. Alcohols emit pollutants, albeit less than petrol, and so are considered as transitional fuels in, say, California's long-term commitment to introducing cleaner vehicles.

Discussion

Oil companies in South Africa have already commenced with the adding of alcohols to South African fuels.

2.3.3.1. Ethanol

About 4 million cars in Brazil are powered by ethanol produced from sugar cane using fermentation followed by distillation to recover the ethanol. Typically, as a fuel in its pure form, ethanol produces 20-30% less carbon monoxide, about 15% less nitrogen oxides and insignificant amounts of sulphur dioxide (petrol contains more than three times as much sulphur, although the amounts are very small). Carbon dioxide release by ethanol-powered vehicles is balanced by its absorption in new sugar cane.

Sao Paulo illustrates some of the success of using ethanol either in its pure form or as an additive to produce gasohol. The city has 1.1 million ethanol-powered and 1.2 million gasohol-powered vehicles. All petrol cars were phased out in the mid-1980's during a complete ban on car imports (this ended in 1990), after which high import taxes have kept imported car numbers low, although these can be converted to run on gasohol.

Significant air quality improvements are predicted if all the vehicles use ethanol, whereas the replacement of the current ethanol/gasohol vehicles of Sao Paulo with petrol-powered vehicles would result in a major deterioration in air quality. One additional advantage of ethanol is that it does not contribute to airborne lead.

In the US, 95% of ethanol is produced from corn (maize) and about 5% from sugar cane or other biomass or organic matter such as wheat, potatoes and sugar beet. It is used as an additive to increase the octane rating of petrol and to reduce carbon monoxide emissions (refer to the earlier section discussing oxygenated fuels). This oxygenated fuel or gasohol, compulsory in winter months in many cities with carbon monoxide air quality problems, is subsidised by the federal government and some States exempt gasohol from their fuel taxes. In Europe, the European Union allows 5% ethanol derived from cereals (wheat, maize), potatoes or sugar beet to be added to fuels (petrol and diesel).

2.3.3.2. Methanol

Methanol, also known as wood alcohol, can be produced from wood, coal or natural gas. Its high octane rating has resulted in it being used in racing cars such as the Indy 500 race cars since 1965. Unlike petrol-powered vehicles, methanol-powered vehicles emit only a few compounds, primarily unburned methanol, formaldehyde NO_x and CH_x. Unburned methanol is much less photochemically reactive than the organic compounds emitted by petrol-engined vehicles, so ozone formation ought to be reduced when using methanol. However, the overall ozone reductions depend on how much formaldehyde is produced as this is very reactive and has a high ozone-forming potential. Formaldehyde is also a suspected carcinogen. Recognising this concern, in 1989 California set standards of 15 mg/mile of formaldehyde as the ultimate standard needed to be achieved by vehicles using methanol. Providing formaldehyde emissions can be kept low, methanol is considered to offer useful air quality benefits compared with petrol, but only as a transitional

step towards the long-term aim of the widespread use of zero-emission vehicles.

There are many practical considerations in methanol replacing petrol. Methanol produces only half the energy as the same volume of petrol, so the fuel tank would have to be twice as large to enable the same range to be driven.⁹⁰ Methanol is highly corrosive, so petrol stations would need new storage tanks and cars would need corrosion-resistant fuel lines and carburettors.

2.3.3.3. Biodiesel: Rapeseed Methyl Ester

The growing surplus of farmland needed to produce food crops in the European Union has increased farmers' interests in growing crops to produce fuels⁹¹, using the 15% of land ('set aside') since 1992. The main focus of attention has been on producing biodiesel from oilseed rape (canola). Oil is extracted from rape simply by crushing, with 3 t of rape yielding one tonne of oil. Most diesel engines can run on unblended rape oil without modification, but they become clogged after several days. To prevent this, glycerine must be removed by separation from the oil. Each tonne of oil is mixed with 110 kg methanol in the presence of a nitrogen hydroxide catalyst and heated to 40-50 °C. The glycerine settles out, leaving a clear thin liquid, rapeseed methyl ester.

Many European countries have begun building rapeseed methyl ester production plants. Austria has more than 100 petrol stations selling biodiesel. Several trials using bus fleets have been attempted. In the UK, Reading conducted trials in 1993 using buses fuelled by rapeseed methyl ester. No engine modification was necessary and emissions of sulphur dioxide, particulates, carbon monoxide, nitrogen oxides and carbon dioxide were reduced for a power loss of 2-5% compared with a conventional diesel engine.⁹² The trials suggested there may be problems with lubricants and the rapeseed methyl ester damages rubber pumps and hoses more than diesel. Despite the overall success of this pilot experiment, wider adoption of

rapeseed methyl ester by European bus and lorry fleets is hindered by the higher cost compared with conventional but more polluting diesel fuels (e.g. twice as costly as diesel in the UK). This points to the need for tax concessions (e.g. cutting duty on biodiesel) to become competitive with fossil fuels. However, producers in Austria claim that they can produce rapeseed methyl ester for the same price as diesel, so the penetration of this biofuel into the market may increase in the coming years.⁹³

2.3.3.4. Compressed Natural Gas (Methane) and Liquid Petroleum Gas

Gas can be used as a fuel for vehicles in the form of compressed natural gas or liquefied petroleum gas. Whereas compressed natural gas is mainly methane gas, liquid petroleum gas consists mainly of propane and butane produced as by-products from oil refineries. Liquid petroleum gas is used extensively in the Netherlands where it accounts for 15% of vehicle fuels. Compressed natural gas is the cleanest fossil fuel and currently provides power for more than 700 000 vehicles world-wide. There are more than 300 000 such vehicles in Italy and more than 230 filling stations (the Italians have been using natural gas for 40 years), more than 200 000 vehicles in Russia, approximately 100 000 in New Zealand, more than 100 000 in British Columbia, Canada and over 100 000 in Argentina.⁹⁴ Currently, there are 100 000 natural gas vehicles in the US. With the stringent emission standard targets applied in California being increasingly adopted by other States it is possible that the number of natural gas vehicles could reach 4 million by 2010. All new buses in Buenos Aires began using compressed natural gas in 1990, whereas Sydney has 250 natural gas buses operating. Budapest in Hungary intends to replace its 400 diesel buses with compressed natural gas vehicles at a cost of \$6 million (R41.7 million, (2000)), but this is expected to pay for itself in four years due to the difference in petrol and compressed natural gas prices. The US Parcel Service plans to convert 2 700 delivery trucks to compressed natural gas in Los Angeles and eventually all its 50 000 vehicles. Brussels introduced a fleet of 20 buses in 1994 powered by natural gas. Mexico City has plans to convert all public transportation vehicles to run on natural gas. Almost all such vehicles have modified petrol or diesel

engines that run on natural gas stored in high pressure tanks located in the boot of a car or on the chassis or roof of a van, bus or lorry.⁹⁵ Compressed natural gas (85%) is also mixed with hydrogen (15%) to form hythane. It emits less hydrocarbons and nitrogen oxides compared with compressed natural gas. Biogas, like natural gas, consists of methane, but whereas natural gas is a fossil fuel, biogas comes from renewable sources. It is produced from the decomposition of organic matter, such as sewage sludge, but it can also be salvaged from waste dumps. Linköping in Sweden, Colorado Springs in the US and Tours in France all have buses running on biogas.

The advantages of compressed natural gas are that it is often cheaper than petrol (e.g. half the price of petrol in the US due to no federal tax being applied) and it produces lower pollutant emissions. Carbon monoxide is reduced by 90%,⁹⁶ reactive hydrocarbons by 50% and there are virtually no particulates emitted. Unlike petrol, no benzene is emitted. However, on the negative side emissions of nitrogen oxides may be higher. It emits less carbon dioxide, but methane is a greenhouse gas so this offsets this advantage with respect to the problem of global warming. It is considered a safe fuel with no fires or explosions arising from using compressed natural gas in vehicles. It is better suited to buses and trucks than cars because it offers only 25% of the energy provided by a similar amount of petrol, so needs much larger storage tanks, causing the vehicles to be heavier and/or some loss of space.⁹⁷

2.4. Conclusion

The world's motor and oil industries have made great progress already in reducing harmful exhaust emissions from modern vehicles and developing fuel specifications.

The programmes for the development of each new generation of engines and emission control systems will bring further improvements in their environmental performance. However, in many parts of the world, including

Europe, the problem of continuing high levels of pollution from older vehicles will remain for at least another decade.

To relieve congestion, together with the consequent rise in consumption of fuel and vehicle emissions, more efficient use of road space will be required, whether or not restrictions are placed on private vehicles entering city centres. Thus vehicles need to be more manoeuvrable and smaller to take up less road and parking space. Guided busway systems can enable additional traffic lanes to be available at a fraction of the cost of light rail systems with much greater flexibility since the buses can operate normally outside the guideway.

Biofuels, methanol, ethanol and ester fuels made from biomass, while having low emission levels, will probably have limited use in the short term because of their relatively high cost of production compared to standard fuels. However, this may be overcome where the raw material is a waste product, or in the long term when diesel and petrol costs rise as their reserves are depleted.

Chapter 3 investigates the current situation in South Africa with regard to transport problems being experienced. Where South Africa will be able to make changes similarly to the Western world it is indicated. South Africa is in a unique transport situation and therefore needs unique solutions.

Chapter 3: The status quo in South Africa

3.1. Introduction and background

The current situation in South Africa, with regards to urban transportation, is investigated in this chapter. It should be noted that the availability of data and the different national priorities (e.g. Reconstruction and Development Plan (RDP) and Growth, Employment and Redistribution (GEAR)) would determine the measures to be introduced to curb the problems experienced.

The road transport sector was chosen as subject because of its importance in environmental, economic and political terms. Its importance and complexity make it a necessary complement to other studies. This complexity, of course, presents problems for analysis; this study therefore concentrates on an overview of international policy, followed by an examination of existing national and local practice and the scope for the introduction of emissions control equipment in case examples of plans, programmes and projects.

Growing South African cities are facing a threefold urban transportation problem:

- Traffic congestion in daily commuter traffic, due to large increases in the urban population and therefore a proportional increase in transport trips. The increased distance between homes and central business districts as cities expand leads to longer journeys and the consumption of more fuel and an increase in car ownership.
- Increased demand for fossil fuel oil is aggravated by the dominance of relatively fuel-inefficient road passenger transportation modes and a predominance of older, less fuel-efficient cars.
- The numbers of poor people who are too poor even to afford travel by public transport, are creating large-scale immobility.

In South Africa, most white workers in the major urban areas lived no more than 7km from their place of work in 1992. African workers, however, lived on average more than 15km from their place of work, with many travelling 100km

or more. Almost 63% of African workers travelled at least 16 km between work and workplace.⁹⁸ This situation is still prevailing and even exacerbated by RDP houses being built far away from urban centres and public transport. Urban areas infrastructure is aimed at transporting people from the more affluent areas to the central business district (CBD), while the outlying disadvantaged areas have little or no transport infrastructure at their disposal. Only half of Cape Town's 381 000 daily commuters are satisfactorily transported to and from work. About 280 000 commuters from disadvantaged settlements lack the roads and railway lines necessary to provide them with satisfactory daily transport to their workplace, because the infrastructure is geared for traffic to the CBD from mostly affluent areas. About 15% of commuters from these areas travel to the CBD.⁹⁹ More or less the same situation is evident in the other major cities of South Africa.

For future planning (also in terms of fuel demand) differences in urban development patterns and transport networks will have to be taken into account. An estimate of the increase in numbers of commuters during 1985-1995 is 7.5% per annum (from a total of 2.3 million commuters in 1985 to 4.8 million in 1995). For urban African commuters, taxis are the most important mode of transport (38.4%) followed by buses (14.6%) and cars/motor cycles (12.8%) while 83.8% of urban white commuters used private cars for transportation.¹⁰⁰ This situation is further exacerbated by the fact that both Statistics South Africa and the Department of Transport no longer gather data with regard to numbers of passengers transported and kilometres travelled. The figures used in this thesis are the latest in this regard.

3.2. Vehicle ownership and usage in South Africa

At present around 52% of the total population live in metropolitan and urban areas. By 2010, over 60% of the population will live in these areas¹⁰¹

The rate of growth in the motor vehicle population has exceeded the rate of human population growth since 1970.

The number of licensed motor vehicles for South Africa is listed in the table below. From the table it is evident that out of the 5 million vehicles on the road 3.5 million are private cars. The registration of new cars per thousand of the population is also increasing steadily as the following figures indicate:

RSA car registration per 1000 population¹⁰²

1970	80.9
1980	97.2
1990	111.2

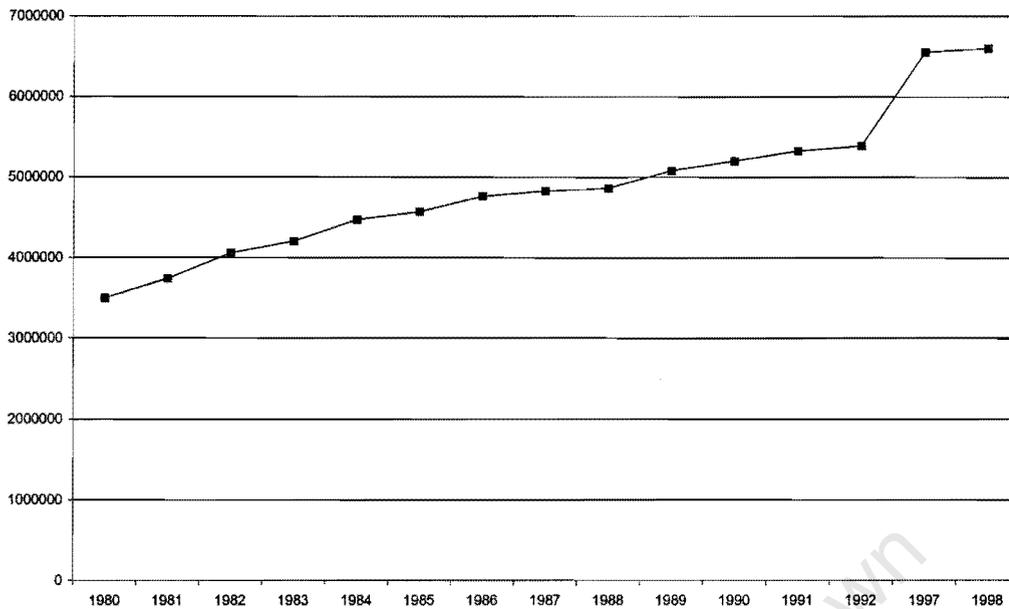
Table 8 Licensed motor vehicles in South Africa¹⁰³

31 December	Total
1997	3 864 614
1998	3 905 761
1999	3 966 252

The above table reflects the vehicle population on the date that the statistics were extracted (31 December) and includes all vehicles that were:

- Licensed on the system or the vehicle licence of which has not expired more than a year before that date;
- Registered and liable for licensing and the date of registration is not more than a year before that date; or
- Pending registration and licensing where the sale of a used vehicle occurred and the date of notice of sale is more than a year before that date.

The white population owns the majority of private cars in South Africa. This situation is, however, changing as more and more of the previously disadvantaged communities obtain increases in remuneration. The Moving South Africa study indicated that the barrier in earnings to own a new car is only R30 000 per year. An older second hand car is obtained which is not well maintained and pollution levels might increase considerably as a result of this.

Figure 2 Total number of licensed vehicles

The figure above gives an indication of the growth in the total vehicle population in South Africa since 1980. This trend is likely to continue. In the period between 1993 and 1996 this Statistics South Africa decided to discontinue the publication of motor vehicle statistics. The National Traffic Information System commenced with the gathering of the data during 1998.

Determination of the future trends in car sales and prices

The table below gives an indication of the average price of a vehicle as well as the number of vehicles sold during each year from 1995 to 1998. In the table it is evident that sales of vehicles increased from 1995 and then proceeded to decrease again in 1997.

Table 9 Retail sales of new vehicles in current prices ¹⁰⁴

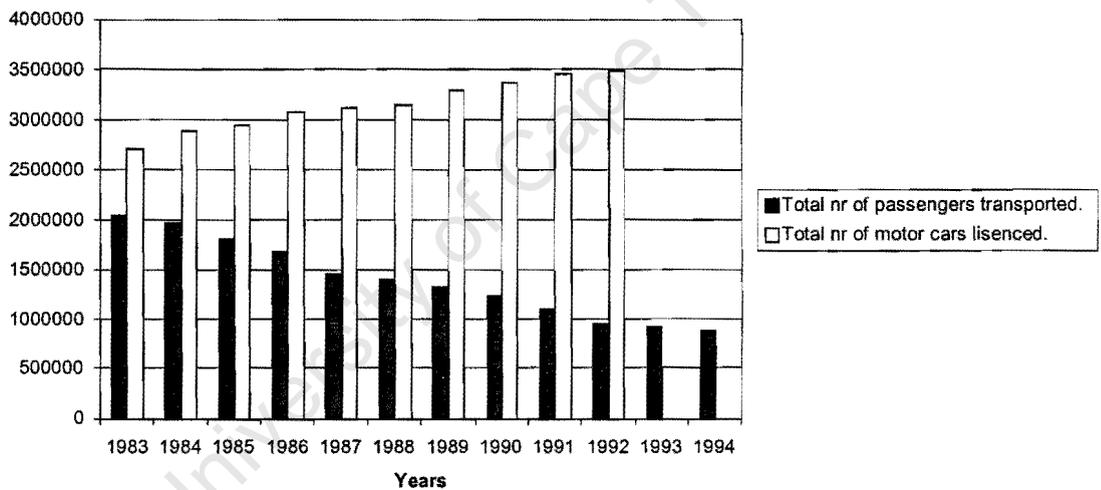
Year	Cars		Light Commercial vehicles		Medium and Heavy Commercial Vehicles	
	Total sales	Average price	Total sales	Average price	Total sales	Average price
1995	236 584	16 400	128 397	9 400	11 803	2 500
1996	249 838	17 800	129 575	9 700	13 567	3 500

Year	Cars		Light Commercial vehicles		Medium and Heavy Commercial Vehicles	
	Total sales	Average price	Total sales	Average price	Total sales	Average price
1997	239 762	18 600	114 354	9 300	12 759	3 300
1998	203 821	16 000	99 078	8 500	11 511	3 000

Note: All values in Rand Millions

Following a graph indicating the retail sales of new vehicles and the upward trend from 1990 onwards as well as the downward trend in the number of passengers transported.

Figure 3 Number of licensed vehicles vs. number of passengers transported



The above figure gives an indication that the motor vehicle population is increasing and a possible explosion in the car population could be expected due to the fact that the previously disadvantaged now earn enough to buy private cars. This is, however, not evident in new car sales but second-hand sales of vehicles. At the same time the number of people making use of public transport is declining sharply.

During 1997, 259 000 second-hand cars and minibuses were sold while during 1998, the number decreased slightly to 251 000¹⁰⁵. This is an indication that people tend to use more private cars and other means of transport than public transportation options. It also indicates the large

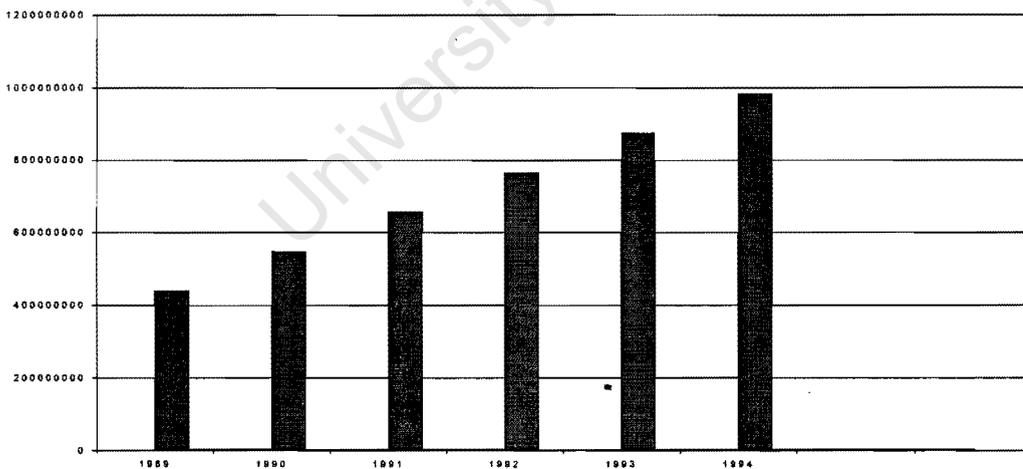
percentage of the population that owns a second hand car, which is generally not well maintained and polluting.

Bus transport

The total number of passengers transported by bus decreased steadily from 1988/89 (733.54 million passengers) to 1994/95 (416.03 million passengers) This indicates an average decline of 7.8% per annum over the seven-year period. These are the latest figures. (An updated Transport Statistics will only become available in April 2001)

The total subsidies received by bus operators from the Department of Transport, municipalities and other sources, increased substantially over the same period. They amounted to R438.097 million in 1988/89, and more than doubled over the seven years, to total R981.849 million in 1994/95 (an increase of approximately 124%).¹⁰⁶ In 1994/95 the subsidies received by bus operators from the Department of Transport totalled R709.188 million.

Figure 4 Increase in bus subsidisation since 1989



The table below gives an indication of the fares paid by commuters for each mode of travel in South Africa.

Table 10 Commuting cost by main mode of transport used (1994)¹⁰⁷

Main mode of transport	Average monthly cost of transport (Rand).
Train	87
Bus	110

Main mode of transport	Average monthly cost of transport (Rand).
Taxi	124
Car, as driver	192
Car, as passenger	70

The South African bus system pricing is distance based. Therefore there are no cross subsidies between people who stay on the bus for only a short distance and the ones who travel further. This, however, carries important equity impacts, since the majority of the longer trip-makers are likely to be low-income users. Based on the estimates presented here, bus passenger transportation ownership and usage cost in South Africa amounted to nearly R981 850 320 in 1995 or approximately 0,2% of the Gross Domestic Product of South Africa.

Buses in South Africa are divided into two major groups, the long distance buses, which carry passengers from the remote townships to the central business district to work and the municipal buses. The buses and bus services are inefficient, unreliable and uncomfortable. These buses are not rider friendly as information regarding routes, tariffs etc. is not readily available. It is therefore difficult for a new user to utilise public transport.

Train transport

Although according to the following table, the number of passengers transported by train was 413 million in the 1994/95 financial year it represents a small percentage of the population. Passenger train transport in South Africa is generally perceived as dangerous, the trains are not well maintained and the stations are not perceived as safe either.

Table 11 Rail passenger transport in South Africa¹⁰⁸

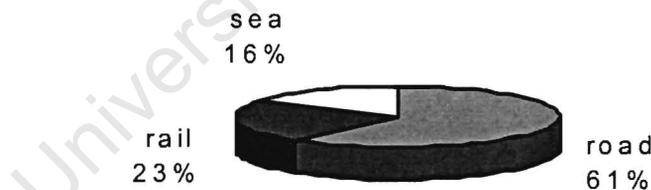
Rail passenger transport: selected data items.			
Data items	Financial year		
	1992/93	1993/94	1994/95
Passenger transported	398 419 443	403 529 816	413 514 679
Operating subsidy (Rand)	979 000 000	1 052 000 000	1 124 000 000
Operating subsidy per passenger trip (Rand)	2.46	2.61	2.71
Operating subsidy per passenger trip (1990 Rand)	1.83	1.77	1.69

The table above gives details concerning the commuters carried by rail (South African Rail Commuter Corporation) and the operating subsidy received by the South African Rail Commuter Corporation. The number of passengers as well as operating subsidies has increased. Although the operating subsidy per passenger increased each year, in real terms the operating subsidy per passenger decreased.

Freight transport

Road freight reached its lowest level in 1993, totalling 400 million tons and proceeded to grow slightly in 1994 to 490 million tons. Freight carried by sea slowly increased ¹⁰⁹ while rail freight figures remained fairly constant. Modal split for freight transport is as follows: road - 61%, rail - 22.7% and sea- 16.2%.

Figure 5 Modal split for freight transport



The use of heavy motor vehicles for freight transport

The impact on the environment by vehicles are all the greater if vehicles are poorly maintained, and conditions in the road freight sector are not conducive to good maintenance. Competition is strong, both inter-modal with rail and intra-modal between road hauliers, with many smaller operators entering the market and capacity exceeding demand, putting pressure on vehicle operators to reduce costs. With deregulation of the industry having occurred

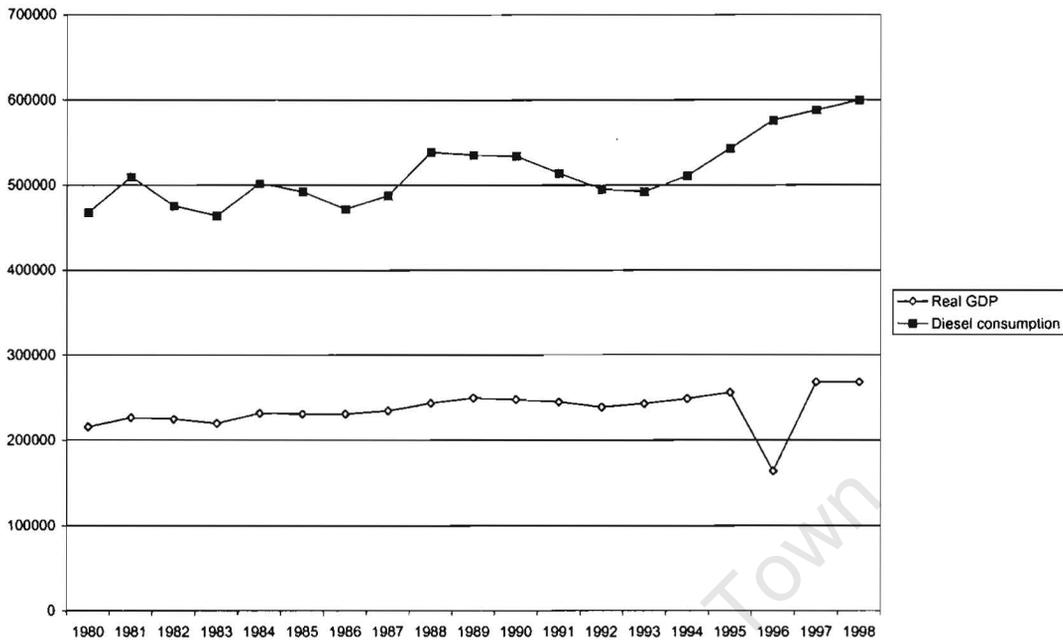
without a planned Road Transport Quality System being introduced, cost cutting often impacts detrimentally on the quality of operation of vehicles. Hauliers speed, overload, drive for long time periods without rest, and spend as little as possible on driver training and vehicle maintenance. Vehicles are expensive and the average age of the South African commercial vehicle fleet is approximately fourteen years.

Heavy motor vehicles cause a number of externality costs that impact negatively on both the biophysical environment and quality of life: noise, vibration, air pollution, diesel consumption and congestion that necessitates expansions of transport infrastructure. For older vehicles, with lower design specifications, these externalities are worsened if vehicles are overloaded - a common practice as policing is virtually non-existent although, as discussed below, steps have been announced that will rectify this situation.

No measures exist at present to internalise the externalities caused by motor vehicles and legislation that exists to curb the air pollution caused by them is not enforced. Growth in the use of heavy motor vehicles for freight transport has been high since the freight transport industry was deregulated in 1989, but the number of vehicles has now stabilised, road freight having captured close to the total market in general cargo (that is, non-bulk) movements in South Africa from rail. The use of heavy vehicles will continue to grow in future in line with growth in the economy, as rail is unable to compete with these vehicles because of their inherent comparative advantages in terms of time savings and convenience of service. In 1997, there were 1.6 million commercial vehicles in South Africa.¹¹⁰

An indication for the use of heavy vehicles is the consumption of diesel fuel. This is compared below to the growth in South Africa's gross domestic product:¹¹¹

Figure 6 The relationship between diesel consumption in South Africa and the GDP of the country¹¹²



As can be seen in the above figure a close correlation exists between the GDP of the country and the diesel consumed. It is evident that the diesel consumed in this country is directly related to the GDP and possible pricing options for diesel need to be further investigated to make use of this relationship to ensure economic growth in South Africa.

The use made of heavy freight vehicles is large: approximately three thousand vehicles per day travel the N3 between Gauteng and Durban. Even modest 'environmental premiums' per trip would thus yield substantial revenues that would fund effective monitoring and policing actions.

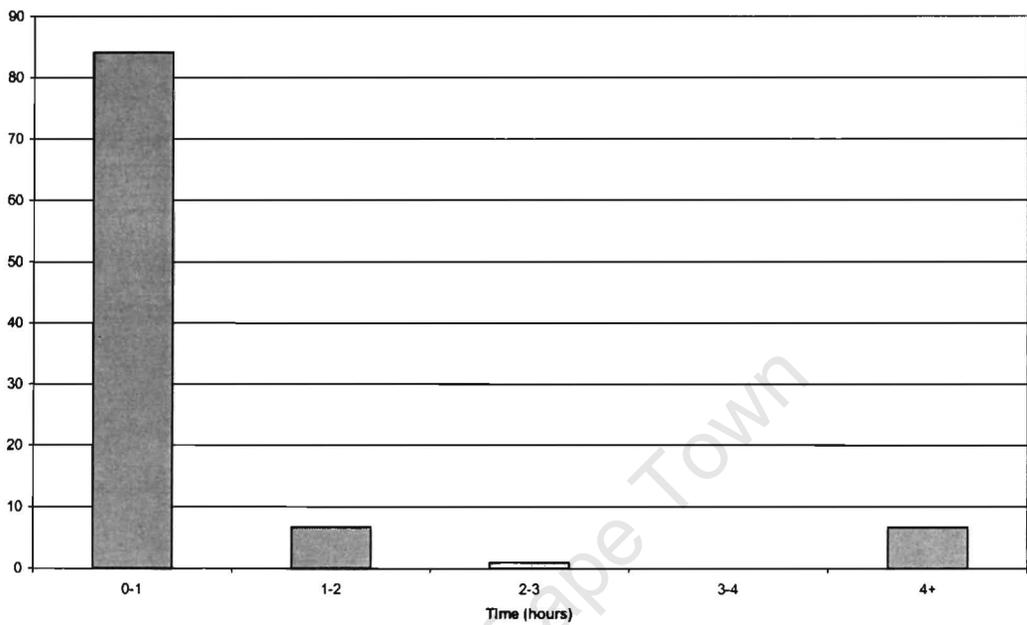
Measures to increase the utilisation of the rail by improving it, making it more reliable, fast and efficient could be introduced in South Africa.

3.3. Travel time in South Africa

The figure below gives an indication of the percentage of workers and the hours of travel for each. It is an average between provinces both for urban

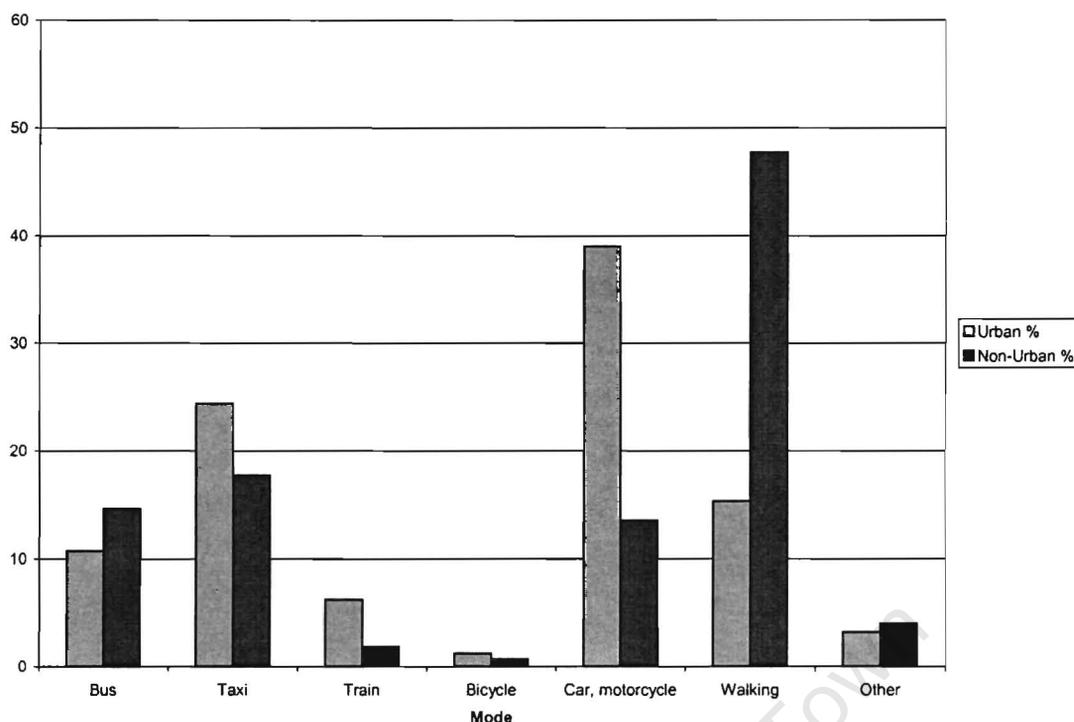
and rural areas. It is alarming to note how many people still travels more than 4 hours to work each day.

Figure 7 Number of workers by travelling time to place of work (1995)¹¹³



The following figure gives an indication on how many people are using the different modes of transport.

Figure 8 Workers by mode of travel to place of work (1994)¹¹⁴



Measures should be introduced to ensure that there are no persons having to travel for more than 2 hours to get to work. People should be moved or work should be sought closer to home. Town planning rules and regulations should be adapted to allow for mixed town planning where residential areas could co-exist with industrial areas where it is safe to live near industries.

As per figure 8, the number of people travelling in an urban area by car is 39% (or 16 085 160) and as urban passenger in either bus, train or taxi is 41.3% (or 17 033 772). This trend is likely to change in the near future as more and more people travel by car and less use the public transport system. The large number of people walking in the rural areas is an indication of the lack of proper transportation. These people need assistance with sustainable transport options. In the short term, these could include bicycles or other low cost transport options as the rural people are generally considered as the poorest people in South Africa.

In 1994, most workers in urban areas travelled by car/motorcycle, followed by taxi, walking, bus, train other and bicycle.¹¹⁵ In the rural areas the ranking is

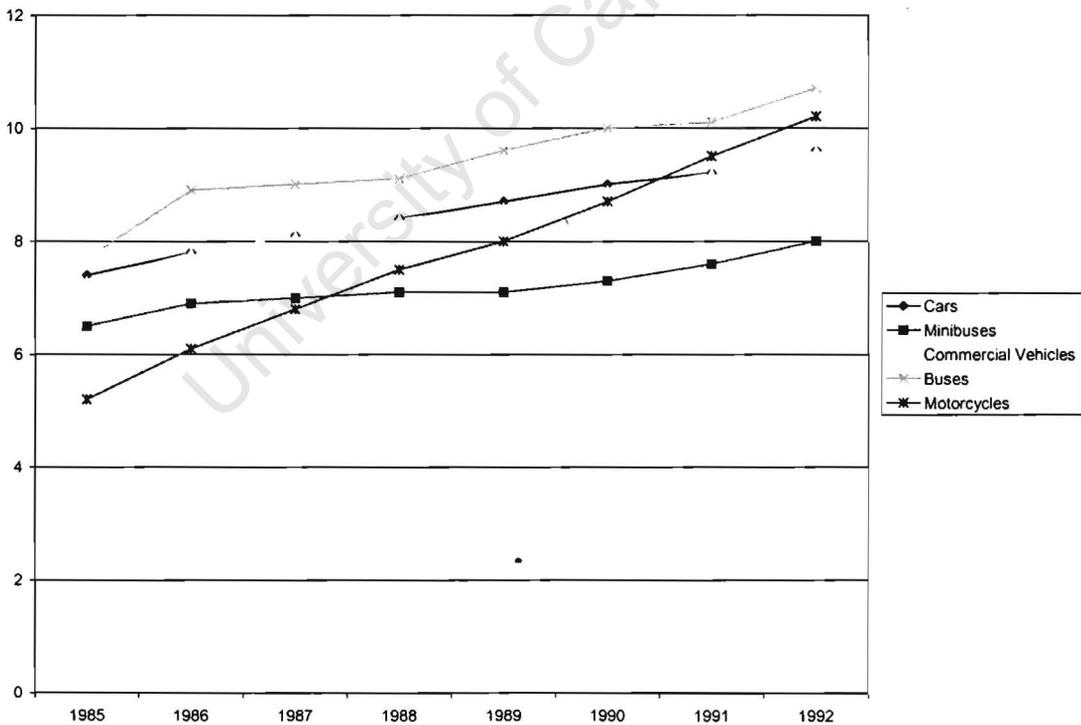
walking, taxi, bus, car/motorcycle, other, train and bicycle. It is important to see the low priority that bicycles receive in South Africa.

In conclusion it is clear that although it is less expensive to travel by means of public transport, the private car is used by the majority of people for the majority of trips. The non-elasticity of the price of petrol, diesel and vehicles is evident. Market forces are not enough to persuade people to utilise the public transport system and bicycles. Some intervention is therefore necessary.

Vehicle age in South Africa

The ageing of cars in South Africa also poses a problem as old vehicles are generally not well maintained, and are polluting from the exhaust pipe as well as oil leaks.

Figure 9 Average age of vehicles in South Africa (years)¹¹⁶



Due to the huge market in South Africa for second hand vehicles and the fact that there is no mandatory scappage of vehicle mechanisms in South Africa it is evident in the above figure that the vehicle ages are increasing with time. It

is anticipated that the ageing of vehicles in South Africa will continue unless a system is implemented by Government to scrap vehicles that are polluting and not well enough maintained, or by controlling the emissions from vehicles.

During a transport study tour in the Netherlands in 1998 it was mentioned that European vehicles that no longer comply with the stringent European emission standards are exported to developing countries. Although this is ethically questionable if one thinks about it those vehicles are still less polluting than the average vehicle in South Africa. Projects should therefore be introduced whereby the European vehicles are used to replace the oldest vehicle of the poorest person in South Africa. The Europeans could possibly get credits for reducing global warming gases by giving or selling the vehicles at a low cost to South Africa.

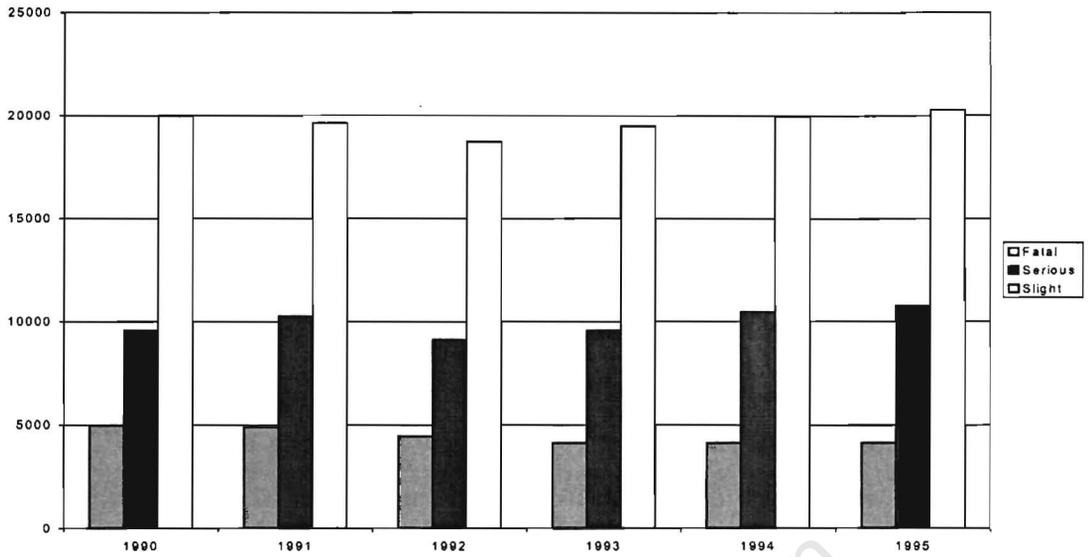
3.4. Accidents in South Africa

The cost to the country for each accident is immense. Accident costs comprise the total costs of traffic accidents, including deaths, injuries, pain, disabilities, lost productivity, grief, material damage, and the cost to task traffic officers to do duty on roads during holidays for accident prevention. The figure below gives an indication of the number of accidents per year as well as the degree of seriousness of each accident for pedestrians, which is relatively high for South Africa.

Note the increase in the number of accidents, as well the degree of seriousness of each accident for pedestrians since 1993 even though the fatalities might be the same or slightly decreased.

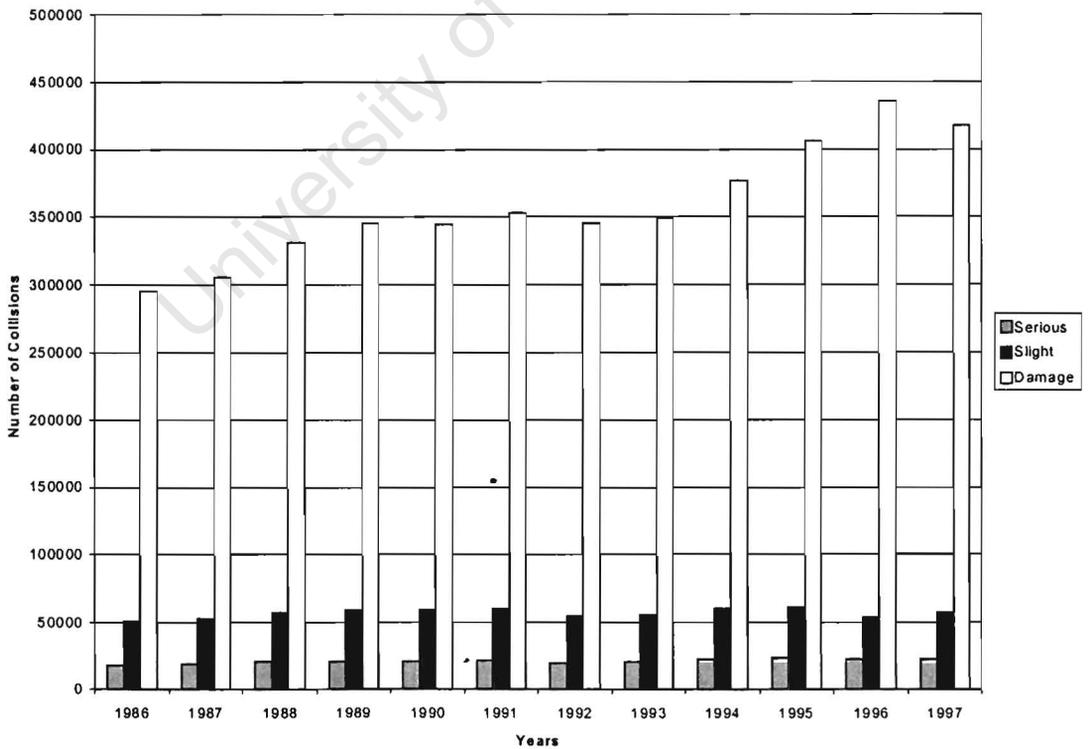
If compared to other first world countries for example the Netherlands, South Africa's road deaths and accidents are significantly more. The Netherlands have an average of 5 deaths per year while 10 000 people die on South African roads per year.

Figure 10 Pedestrian casualties per degree of seriousness¹¹⁷



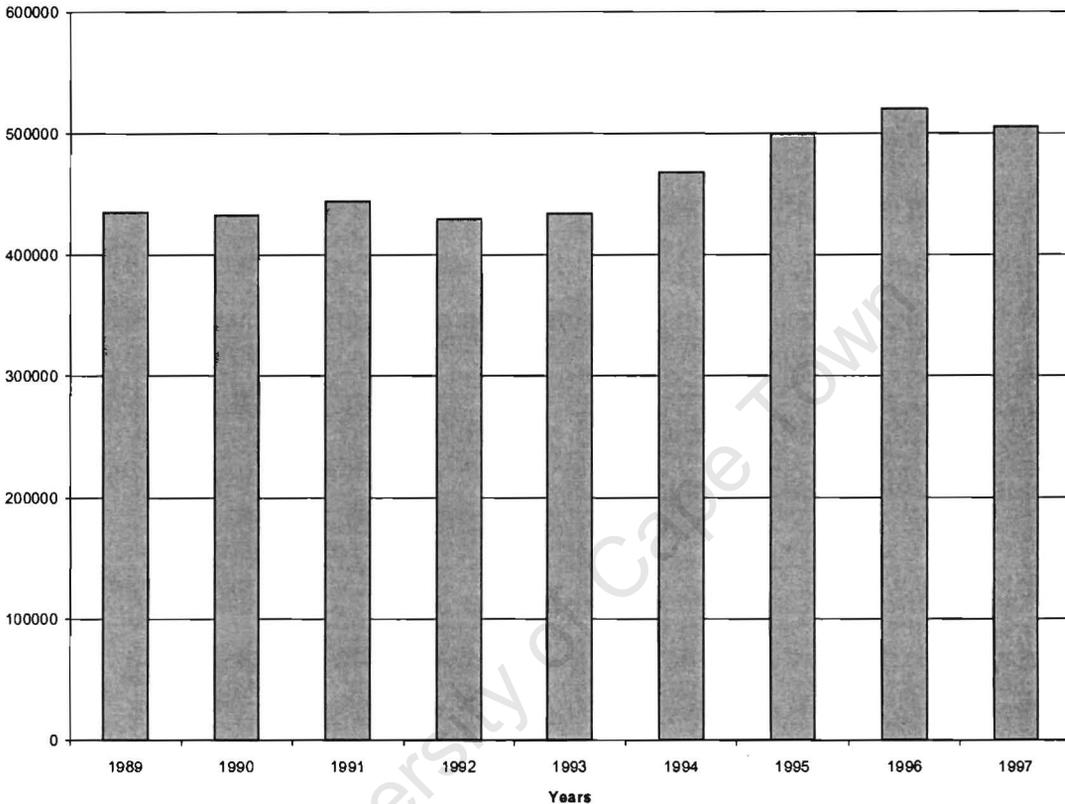
The figure below gives an indication of the collisions and the degree of seriousness and the total for each year.

Figure 11 Collisions per degree of seriousness¹¹⁸



Numbers of accidents will continue to increase with the increase in the vehicle population. The cost to the country will also continue to increase as health costs and vehicle costs increase.

Figure 12 Total collisions per year¹¹⁹



The cost to the economy for every accident in South Africa in 1996 rand is as follows: For every fatal accident the cost is R290 919,¹²⁰ for a serious accident the cost is R72 065, for a slight accident the cost is R19 186 and for damage is R13 641 per accident.

These costs could, however, be avoided if people are persuaded to use the public transport options available. This will also have a positive effect on the viability of the public transport system as well as the congestion and health problems. The total saving to the country could amount to several percentage points of the GDP. The welfare effects will also be positive as travelling by train or bus is generally much cheaper than by car. It might therefore be worth

while to spend some money to improve the existing public transport systems and also to further investigate light rail or high speed rail options.

3.5. Congestion in South Africa

Most congestion occurs on the main arterials leading into the central area, at major intersections and where freeways discharge high volumes of traffic into the general road system. Traffic in the central area itself is regulated by the signal system in operation but tends to be fairly uniform most of the day.¹²¹

A significant amount of congestion costs could be saved by investing in the establishment of safe, reliable and efficient public transport options. The parking areas that will no longer be used as numbers of private vehicles in the cities decrease could then be used as green open spaces in the city or where these are within a building it could be transformed into gymnasiums for the people who work in that building.

If bicycle lanes are introduced and people are encouraged to cycle to work rather than drive, by giving them incentives, the parking area could be replaced by exercise or workout areas.

This will therefore have a positive effect on the general wellbeing of the people. Savings to the individual by not using a private car and not having to pay for parking could be significant.

The positive effect this will have on the economy by giving delivery vehicles and other economically active vehicles the right of way on the roads will also have significant spill over effects.

3.6. Air pollution in Urban Centres of South Africa

During 1995 the Department of Minerals and Energy embarked on a project to determine the air quality in South Africa in order to calculate or model the effect road transport has on the air quality in South Africa¹²².

The following table gives an indication of the findings of the project with regard to air pollution monitoring by different entities in South Africa.

Table 12 Agencies that monitor vehicle related pollutants¹²³

Regional Centre or Monitoring agency	Site	O3	NOx	CO	NMHC	Pb	Validity
Impala Platinum	Springs		✓				A
Cape Town Munic	City Hall		✓		✓	✓	B
	Oranjezicht	✓					B
Milnerton Munic	Table View		✓				B
	Bothasig		✓				B
Pretoria Munic	Sunnyside	✓					C
East Rand: Airkem	Esterpark		✓				A
	Illiondale		✓				A
	Rhodesfield		✓				A
Johannesburg Munic	City Hall	✓	✓	✓	✓	✓	B
	South Hills	✓	✓		✓		B
	Newtown	✓	✓	✓			B
Port Elizabeth Munic	Greenacres	✓	✓			✓	B
Vaal Triangle	Vanderbijl-park	✓	✓				B
	Three Rivers	✓	✓				B
	Sasolburg Res	✓	✓	✓	✓		A
Durban Waste Water Management	Southern Works	✓					A
	Univ Natal	✓					B
	City Hall					✓	A

A: Operate according to standard procedure, data probably valid

B: Operate approximates standard procedure, data could be questionable

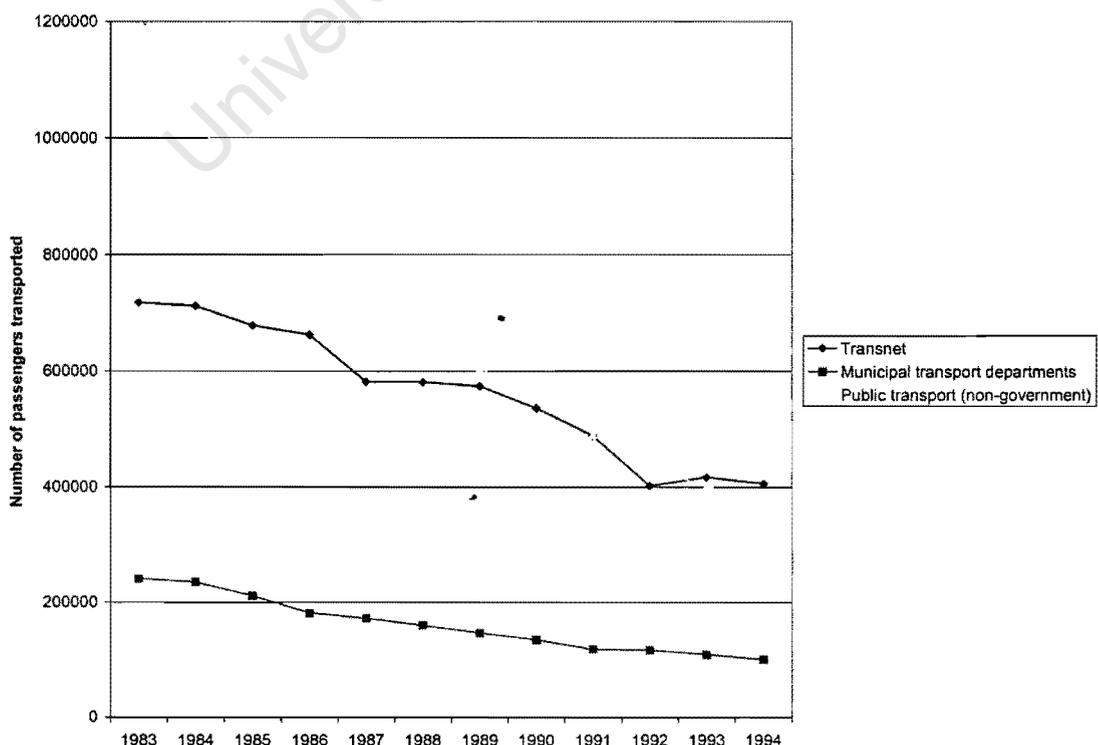
C: Do not operate according to standard procedure, data is probably invalid.

What is clear out of the above table is that only a few sub-areas of municipalities or towns operate according to standard procedure. And the areas where standard procedures are followed not all the pollutants are measured. The gathering of data is seen as one of the barriers to air pollution control in South Africa.

What could be determined from the air quality data correctly gathered was the following. With the exception of lead, emissions of all types are growing rapidly over time, reflecting the growth in traffic generally. The rate of increase in pollution has almost matched the growth in traffic.

It is, however, understood that coal burning contributes to this to a large extent. This will start to decrease when the poverty and job creation targets are realised in South Africa. In the mean time catalytic converters should be made mandatory for all new vehicles to commence the decrease in the urban air pollution in South Africa. This should be seen as a first step towards clean air in the cities.

Figure 13 Public road transport services, passengers ('000) transported¹²⁴



A vehicle population explosion resulting in an increase in the number of vehicles on the road will have a direct impact on the environment and the people.¹²⁵

The relevant studies regarding noise pollution have therefore been done, but it has not been implemented or enforced in South Africa. In the graph above it is evident that the number of people using public transport are decreasing. The use of private vehicles is therefore increasing which will have a negative effect on the noise pollution in the cities in South Africa.

The above figure further gives an indication on how the public transportation users have declined in the past 12 years. This is also an indication of the significant increase in the car population, which is expected in the near future, as the only other transport mode that has increased significantly is the private car mode.

By creating incentives for people to start using public transport and bicycles the noise pollution levels will decrease.

3.7. Resource Consumption of fuels and vehicles

The use of fossil fuels contributes to the greenhouse effect that is of international concern. While South Africa's contribution to international greenhouse emissions is small, there is little doubt that the country will be required sooner or later by international pressure to reduce its emissions.

The use of fossil fuel will continue to grow as a result of growth in the use of private motor vehicles and heavy motor vehicles. This growth will be increased if the age of the vehicle fleets continues to increase and if maintenance is poor - as is expected.

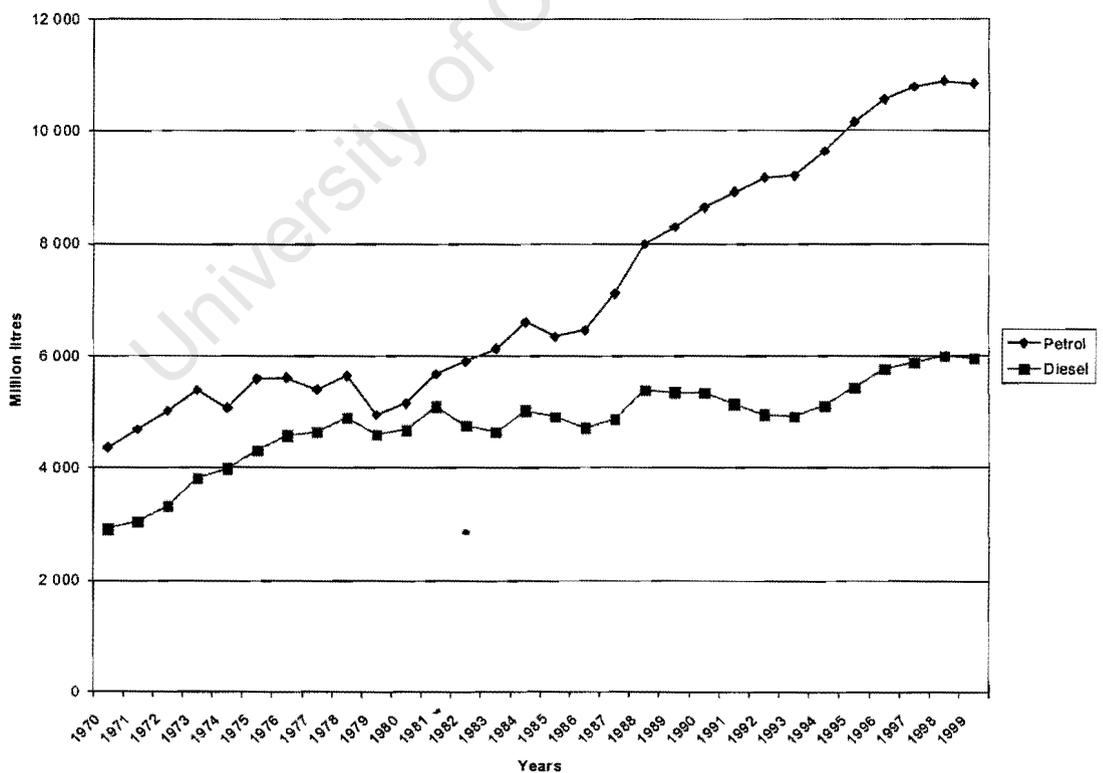
A special problem facing the country is that the demand for petrol is growing faster than that for diesel fuel, which threatens to require an increase in

refinery capacity or the import of refined petroleum - both actions that are accompanied by environmental risks.

Transport of energy and goods accounts for approximately 24% of total energy consumption. More than 90% of transport energy is derived from liquid fuels.¹²⁶ To illustrate the growth in the consumption of petrol and diesel in the transport sector see the figure below.

The impact on the environment by vehicles therefore include the destruction of natural habitat, water pollution, air pollution, ground pollution, the costs of oil spill clean ups and subsequent habitat loss that are not paid by oil companies, oil exploration subsidies, and government expenditures on national defence to protect fuel production sites.¹²⁷

Figure 14 Consumption of oil products for transport in South Africa.



Note the sharp increase in petrol consumption since 1986. It is expected that this trend will continue even further as the population grows and private vehicles are being sought.

South Africa can save millions in foreign exchange if less oil is imported. This could be achieved by introducing energy efficiency measures in the transport sector and by creating incentives for people to start investigating other options to a petrol vehicle.

South Africa should commence to investigate the establishment of industries to manufacture electric vehicles, hybrids and fuel cell cars. Alternative fuels e.g. LPG, CNG and hydrogen need also to be investigated in South Africa.

3.8. Life cycle analysis of vehicles in South Africa

3.8.1. Tons of waste per automobile

The production of one automobile generates more than 24 460 kg of waste. The scrapping again generates about 270 kg of waste¹²⁸. These figures are based on calculations which consider the waste generation during the entire process of car production - from mineral mine to the body-work and from the oil borehole to the dashboard - as well as the waste generated during the shredding process of the car at the end of its life-cycle.

A typical German automobile with an average weight of 1 078 kg consists of:

Table 13 Materials used in the production of a car

Iron and steel	64.9%
Non-iron metal	7%
Plastics	10.8%
Elastomers (Rubber)	8.5%
Glass	4.1%
Textiles	1.7%
Paint	1.3%
Wood, cardboard	1.4%
Wax	0.3%

Most of the waste generated during production is metal, plastic, and glass. These materials make up 87% of the car's weight. The waste balance for a typical car appears as follows:

Table 14 Waste created by the production of a car

Material	Mass in vehicle (kg)	Waste (tons)
Steel and iron	700	4.9
Non-iron metals	76	18.26
Plastics	117	0.93
Glass	44	0.37
Total	937	24.46

The number of new cars sold in South Africa was 314 410 in 1998¹²⁹, including passenger vehicles, commercial vehicles and motorcycles.

South Africa produces approximately 400 000 cars per year therefore the 9.7 million tons of waste is produced in South Africa as a result of the motor manufacturing industry.

With the vehicle population increasing at the current rate new landfill sites will have to be obtained in increasingly shorter time periods.

It is recommended that South Africa commence with a programme to recycle vehicle parts in order to slow down this tendency. Recycling combined with projects to decrease the utilisation of private vehicles could save the economy of South Africa significant amounts of money.

3.8.2. Production of oil in South Africa

In 1999, coal production totalled 219 million tonne ¹³⁰ of which 154 million tonne was sold locally. About 60% of local coal consumption is used to generate electricity, a further 30% was used for liquid fuels production. The

production cost of a ton of coal is approximately R30-R45 while the costs necessary to rehabilitate the environment for an open cast mine is approximately R2-R3 per tonne.

The 30% that were used for liquid fuels production could decrease if fuel efficiency measures are introduced in South Africa. The impact on the environment as a result of expected reduced coal mining could also reduce which will have a positive effect on South Africa's image internationally.

3.8.3. Environmental/health criteria for South African purposes

Environmental issues are likely to become increasingly a part of strategic decision-making. Environmental decision-making is complex because of its multi-disciplinary nature and the lack of understanding of how the environment functions, and just what environmental abuse is doing to populations now and in the future. However, since the production and use of energy are major causes of environmental problems, strategies and policies dealing with environmental problems will be directed increasingly at the energy economy. Likewise, energy policies will become increasingly environmentally conscious.

In considering approaches to deal with environmental problems, it is important to differentiate between management principles underlying the design and implementation of environmental policies, and actual strategies, which are formulated to deal actively with environmental problems.

Management principles include the following:

- Introducing sustainable development to maintain a proper balance between people, capital, materials and the environment.
- Redefining energy costs, to reflect hidden costs of pollution in its various forms and to prevent the cost of pollution being passed on to other groups and generations.
- Compensating the poor by assisting rural areas to meet their energy needs more efficiently and thereby avoiding an increase in pollution.

- Internationalisation and decentralisation of policy decisions. There is a real need for co-operation across country borders, irrespective of economic and security relationships.
- Integration of institutions involved in policy-making
- Stressing proactive or “anticipatory” policies.

Important strategies to combat environmental problems include changing the available transport options, developing alternative and renewable energy sources, investment in energy conservation and efficiency, and a radical cultural change towards transportation.

3.9. Economical impact

3.9.1. The benefits of transport

Transport is important for both the production and the consumption sides of the economy. Regarding consumption, transport offers the opportunity to enjoy the benefits of access to places at a distance, such as city centres, beaches and natural areas. It allows location of activities over a larger area, enabling wider choice of dwelling places, work places, shopping centres, schools, health services, recreational activities and so on. The current trend is that the distance between main activity grows each year, which translates into more mobility.

On the production side of the economy, transport can yield other benefits:

- Economies of scale, by concentrating economic activities;
- Specialisation of production;
- Reduction of the total logistical costs of economic production, including costs of storage.

Transport services also require the manufacturing of vehicles, building of infrastructure, maintenance and operation of vehicles and so on. And these activities generate demand for other goods and services. So the

consequences for transport of policy measures to curb the use of the private car may translate into impacts on many economic sectors.

3.9.2. Transport prices and modal split

Transport policies to reduce the use of private vehicles affects the price level of transport in several ways. Price increases can be caused by both tighter standards and higher use-charges. Lower fixed charges and increased efficiency will lead in the opposite direction. Examples of cost reduction caused by increased efficiency are a reduced accident rate and higher utilisation of infrastructure capacity. It is rather complex to determine what the net effect on transport prices would be. Also, elasticities are poorly understood, as the price changes of interest are bigger than the range normally experienced in transport markets. Matters are even further complicated because this dissertation presents no accurately defined set of policy measures but only some general policy outlines. Hence, this section only indicates the overall magnitude of price changes that could be expected from the policy options presented.

3.9.2.1. Passenger transport

The variable costs of car traffic will increase. The average level of fixed charges will also rise. Total costs for car users – fixed and variable – rise by the same rate as inflation, which is currently approximately 9%.

The cost of public transport will also increase. Covering infrastructure and external costs might increase rail tariffs. In general the tariffs for urban public transport can be expected to increase more than those for intercity rail services (similar to the differentiated price increase for car traffic). Efficiency improvements or changes in the level of compensation related to public service obligations will influence the resulting price increase.

The price changes expected for car traffic (use-charges) and public transport are of the same order of magnitude. A substantial shift to public transport and

other no cost options like walking and cycling is necessary before any of the positive effects mentioned will be realised.

3.10. Costs and benefits

Two kinds of costs and benefits need to be distinguished: financial and non-financial. The financial impact is fairly clear e.g. higher costs for vehicles due to stricter environmental standards or reduced infrastructure costs caused by better capacity utilisation. The non-financial costs and benefits may require more examination. The main non-financial consequences are probably increased mobility. Higher use-charges, for instance, will influence behaviour: some marginal trips will not be made any more. An example of a non-financial benefit is reduced personal distress caused by a reduction in traffic accidents. Welfare can thus be affected by both financial and non-financial impacts, as this section will discuss. The distinction will be made, but in the end only the impact on total welfare is relevant.

3.10.1. General

One of the main aims of transportation is to increase economic efficiency, which relates to both financial and non-financial impacts to increase welfare. Two examples illustrate this relating to environmental standards and mobility.

- Stricter environmental standards will increase the costs of vehicles and at the same time reduce environmental costs. Internalisation means tightening standards to the point where the marginal costs of abatement – the costs required to avoid the “last” kilogram of pollution – equal the marginal benefits. This is the optimal situation: any stricter or looser standards will lead to less than optimum welfare.
- Each trip has its own social costs and benefits. A trip contributes to welfare only if the benefits are larger than the costs. Internalisation aims at a situation where all trips with a welfare gain are made and trips leading to

a welfare loss are avoided. This leads to maximum welfare. In some circumstances a little less mobility can increase welfare.

In general, the recommendations will increase overall welfare; the benefits will be higher than the costs.

3.11. Economic growth and employment

This section discusses the impact of increased private transport prices on GDP growth and employment, taking into account the inter-linkages and dynamics of the economy. It includes examination of the economic consequences of reduced traffic growth, but excludes non-financial impacts on welfare. Hence the outcome of the analysis should be balanced with the relevant non-financial impacts. The complexity of the economic process and the role of transport in it can be analysed with the help of macroeconomic models.

The South African economy has performed badly during the past two decades. From 1960 to 1969 an average annual growth of 5.8% was achieved. From 1970 to 1975 the average annual growth rate was 4.2%, but from 1975 to 1980 it was 2.7% and from 1981 to 1990 it was 1.0%.

With population growth exceeding Gross Domestic Product (GDP) growth, per capita income has declined at an average annual rate of about 1.5% for the past decade. This being an indication of the poverty in South Africa but in contrast to this the vehicle population is increasing.

In South Africa the car population increased by 4.12% per annum¹³¹ while population increased at 2.78% per annum for the period 1970-1980. Between 1980 and 1990 the car population increased at an annual rate of 3.85% while the population increased at an annual rate of 2.54%. The vehicle population will continue to increase unless the intervention takes place to curb the use of the private vehicle is taken into consideration.

The primary effects of transport policies are expected to be significant welfare gains. The main responses are likely to be technological change and increases in operational and organisational efficiency. The increased efficiency consequent on these recommendations should ensure that industry as a whole remains competitive. It is expected to have a positive effect on GDP growth and could have a small positive effect on labour markets.

It may lead to political costs of adjustment, for which additional policy measures could be adopted. This makes it possible to achieve both economic efficiency and the desired distribution of costs and benefits, so long as the additional measures are applied in ways that do not undermine the incentives that these recommendations are designed to produce.

The adjustment to more efficient economic conditions will also have costs for agents that benefit from current distortions. The benefits from recommendations, however, will outweigh the costs. Again, any compensation judged necessary to ease the adjustment period should be provided in ways that do not undermine the incentives that the measures are designed to produce.

Depressed economic growth has resulted in low employment growth rates. Since 1974, the labour absorption capacity of the formal economy decreased and only 1.2 million employment opportunities were created for the 4.7 million new entrants to the labour market. The number of people dependent on subsistence agriculture, plus those operating in the informal sector and the number of unemployed, increased to 5.8 million.

3.11.1. Competitiveness

The competitive position in South African industry is affected in two ways:

- More expensive transport resulting from stricter vehicle standards.
- Reduced costs from congestion and less loss of production from traffic accidents.

The net result can be expected to be positive for business as a whole. The question is how costs and benefits are distributed among sub-sectors, with the consequences for industries that compete in international markets most relevant. As no detailed analyses of the consequences for these industries are available, only some general remarks can be made:

- Transport intensive industries face both higher transportation costs and lower congestion related time losses. The net effect depends on specific circumstances.
- The policy measures to be selected largely determine the distribution of costs and benefits among sub-sectors.

These general considerations lead to the conclusion that it is unlikely that South African competitiveness will be harmed by these measures. Some distortions require attention, though, especially differences in fuel prices among countries and the position on the South African market of non-South African transport companies that will not have to comply to the new vehicle standards. The gain in economic efficiency, however, seems to offer enough opportunities to remove such distortions.

3.12. Economic indicators in South Africa

Useful indicators for the effect that transport fuel has on the economy of South Africa are as follows:

- the ratio of petrol to diesel consumption
- the ratio of total petrol consumption to total population
- the ratio of total petrol consumption to GDP
- the ratio of diesel consumption to GDP

These indicators are provided below:

Table 15 Indicators of the effect fuel has on the economy in South Africa

Petrol/Diesel consumption.			
Year	Petrol (kl)	Diesel (kl)	Ratio
1992	9 170 436	4 950 259	1.85:1
1993	9 202 067	4 939 774	1.86:1

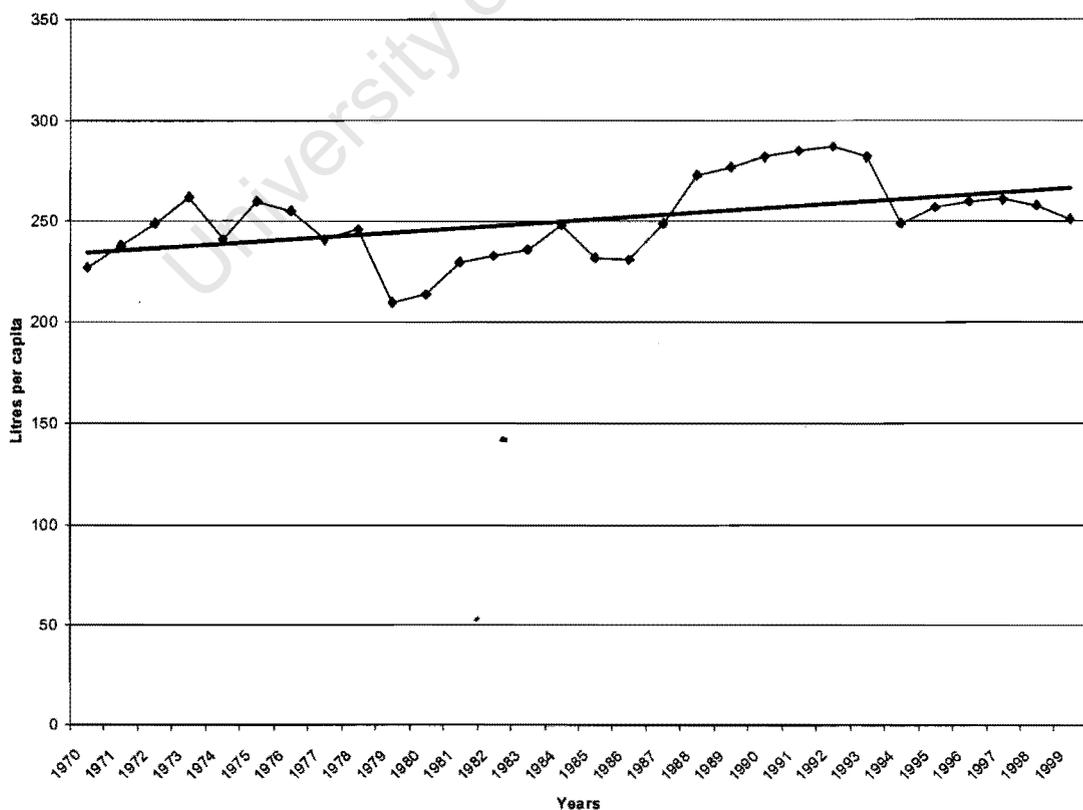
Petrol/Diesel consumption.			
Year	Petrol (kl)	Diesel (kl)	Ratio
1994	9 629 570	5 109 720	1.88:1
1995	10 153 000	5 432 000	1.86:1
1996	10 566 000	5 759 000	1.83:1
1997	10 781 000	5 878 000	1.83:1
1998	10 886 000	5 996 000	1.82:1
1999	10 832 000	5 946 000	1.82:1

Note kl = 1000 litres. ¹³².

More petrol than diesel is consumed in South Africa. This creates an imbalance which government is currently trying to eradicate, by investigating whether diesel midibus taxis could be a possible solution for South Africa. This project is further discussed in Chapter 5.

This implicates that the petrol consumption figures per population is significantly high. The growth in the petrol consumption per capita is graphically shown as follows:

Figure 15 Petrol consumption per capita for South Africa



The above graph gives an indication of the growth that is taking place in the consumption of petrol in South Africa while the Table below indicates the important role that the consumption of petrol plays in the economy of South Africa.

Table 16 The importance of the transport sector in the Gross Domestic Product (GDP) (million Rand)

	1993	1994	1995	1996	1997	1998
At current prices						
Gross Domestic Product at market prices	426 132	482 119	548 100	614 943	680 213	737 813
Transport and communications sector	33 972	38 297	44 538	51 787	57 558	63 489
Percentage of GDP	7.9	7.9	8.1	8.4	8.5	8.6

The petrol consumption comprises therefore a significant amount of the GDP, which is an indication of the importance of liquid fuels in South Africa. Efforts to alleviate high utilisation of fossil fuels will have an impact on the economy of South Africa. If the population makes more use of public transport but still become more productive due to the fact that the public transport system is very efficient and reliable, people will experience less stress, fewer road traffic accidents will occur and this should have a positive effect on the GDP of the country.

If the import and export costs also are taken into account the reduction in the use of fossil fuel will have a positive impact on the GDP of the country.

3.13. Absolute poverty

If poverty is viewed in relation to the transportation problems experienced in South Africa, approximately 5 to 10% of the total population of South Africa is categorised as "striders" ¹³³ which means that these people do not use motorised transport. Walking or cycling is adequate for the trip distance mostly undertaken. However, 10% of the population is categorised as

“stranded”. These people cannot afford public transport due to cost and access. They have a very low household income, reside in ex-homelands, informal settlements or townships. They might walk or cycle for more than 30 minutes one way out of necessity and not choice. Approximately 40% of the population is categorised “survival”. This category is captive to a mode within public transport and is cost-sensitive. They also have a low household income and also reside in ex-homelands, informal settlements, townships or inner city.

The people that are affected by poverty and prices comprise more or less 50% of the population of South Africa.

If the recommendations made in this dissertation are implemented at least the urban population will become more mobile with less cost associated with mobility.

3.14. Prices

Double-digit inflation has occurred in South Africa since 1974. It appears, in fact, to have become a structural characteristic of the economy. The inflation rate as measured by the consumer price index accelerated from an average of 3.8% per annum from 1960 to 1973 to 12.0% during the period 1973-1979 and to 14.7% during 1980 to 1989.¹³⁴ The inflation rate is, however, decreasing rapidly and is now a single digit figure.

The primary concern of these measures is economic efficiency where efficiency of transport markets can be improved by government intervention. However, efficiency is not the only criterion. Fairness - the sharing of costs and distributional effects - is also a politically relevant target. Both efficiency and fairness have to be factored in. For example, when high costs for capacity expansion would call for marginal charges leading to significant over-coverage of historic costs, a compromise can be found by deviating from strict marginal pricing or through lump-sum redistribution of excess revenues. From an efficiency standpoint, these are second-best solutions, in favour of

fairness. Clearly normative - i.e. political - decisions have to be made in such cases.

The principle of fair and efficient pricing should be applied not only within the transport sector, between different modes of transport, but also in the economy as a whole. In so far as transport causes higher (external) costs than some other economic activities, some transport prices should be increased and prices for other, environmentally less harmful activities decreased correspondingly. Such an approach could yield reductions in taxes on labour, capital and production.

3.15. Conclusion

Of particular concern in South Africa is the likelihood of increased automobile use by the previously disadvantaged as they move into higher income groups. This may lead to automobile-oriented societies that reduce the viability of walking, bicycling and transit, reduce the quality of transit service, and create traffic barriers to pedestrians. Based on experience in other cities this is likely to reduce total travel choices, especially for lower income and physically disabled residents, increasing inequity.

It is important, however, to know which modes should be preferred and what the balance should be, as it is not feasible that all private car travel can be halted. The next chapter considers trends and scenarios to indicate the worst transport related problems experienced in the 5 major cities in South Africa.

Chapter 4: Trends and Scenarios

4.1. Introduction

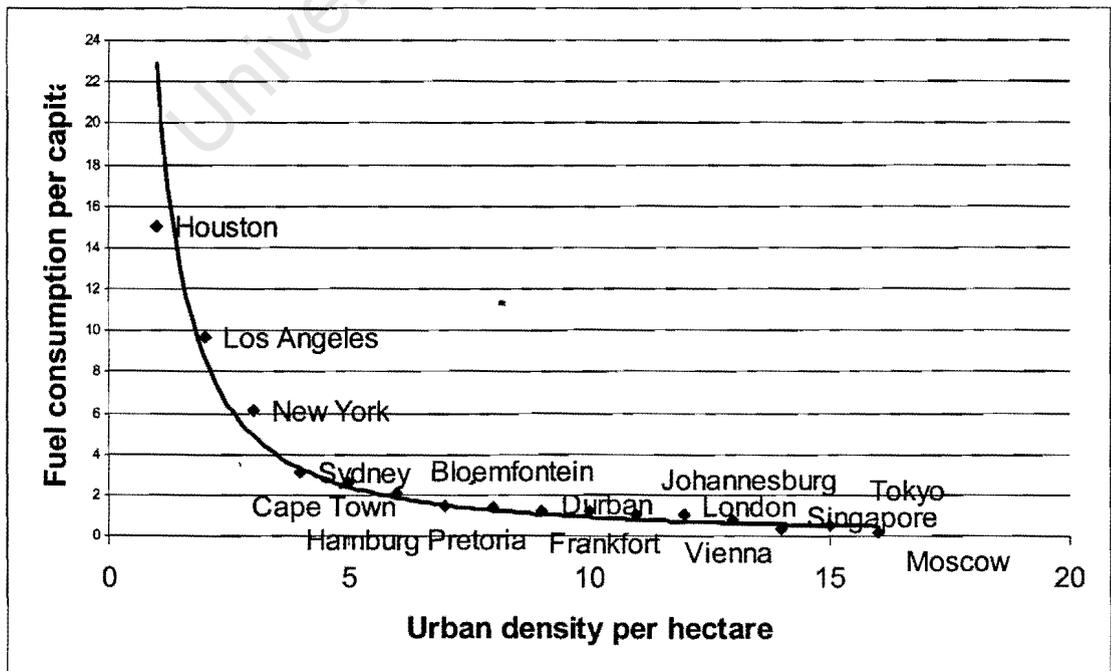
Chapter 3 reported on the current situation in South Africa. This chapter will now investigate the future situation in South Africa if current trends in the growth of the private car population continues.

South Africa has a window of opportunity now to include transportation options into the current GEAR strategy to replace the current transport system with sustainable transport options for the urban populations in South Africa as a first step in the process and then moving to the rural areas to create sustainable transport opportunities there as well.

4.2. Urban density

The problem always arises when comparing one city against another as to whether a comparison is valid on the basis of size, population or any other parameter.

Figure 16 World cities fuel consumption in Giga Joules per capita



In order to compare South African cities densities and therefore viability of public transport to that of other cities, it has been assumed that the density of the city is a function of the fuel consumption per capita which in turn is an indication of the viability of the public transport system of that city. The figure above has been drawn for a number of world wide cities on the basis of fuel consumption per capita and urban population density in Giga Joules per capita. The larger number of cities analysed show that the trend is well established.

This figure shows that fuel consumption per capita is strongly correlated with population density. At the one extreme is Houston with a very low population density, whilst at the other is Moscow with one of the highest population densities and the lowest fuel demand.

It has been shown that the denser the city the more viable is the public transport system in that city. The only city in the world with a viable public transport system is Singapore¹³⁵. South African cities are therefore not dense enough to make public transport viable. Town and regional planners in South Africa should therefore commence with taking transport problems into account when planning a town.

Town and regional planning in South Africa still do not have a limited space to work with like most European planners. This has unfortunately lead to urban sprawl in all South African cities and towns which was intensified by the apartheid laws of the country at the time. Generally planning is done without taking into account the transport problems that might arise or the impact on the environment it might have. The new RDP houses are also not well planned and are built outside towns on new sections of land without public transport.

Integration of land-use and transport planning is a prescription acclaimed by almost everyone but whose implications in practice often remain obscure. It must mean, however, at least three things. First, that the land-use

implications of transport and transport infrastructure proposals are always considered. It is not acceptable for development pressures associated with new roads simply to be superimposed on existing development plans: they should be considered as part of the planning process. Second, the transport and consequent environmental implications of development plans and planning decisions should automatically be taken into account. Neither of these steps is easy. Relationships between land use, transport and the environment are neither simple nor deterministic and it is certainly not the case that planners can plug policies or development proposals into convenient models that will provide the answer in terms of longer-term effects on land-use or travel patterns. But planners are accustomed to living with uncertainty. What is important is that the interactions should be considered as much and as far as possible: undesirable consequences are then less likely to be left out of account altogether. The third requirement relates to mechanism. Undoubtedly, the integration of land-use and transport planning must involve some institutional change. Whether this entails merging departments or closer co-operation and functional integration is perhaps not the most important question. What really matters is breaking through bounded rationalities in both land-use and transport planning; changing the thinking, for example, that has implicitly assumed car ownership in locational decisions or defined transport problems, and therefore solutions, in predominantly engineering terms.

A considerable amount of research, both theoretical and empirical, now points to a set of principles for land-use planning that could reduce the need to travel and encourage the use of environmentally friendly modes. It should be stressed that these are indeed principles that have to be interpreted in specific localities rather than blueprints for ideal development patterns. The principles concern the location and the separation of activities and the nature of the environment in which movement takes place.

A key principle is to locate developments that generate a great deal of movement in places where they are accessible by foot, bicycle, and public

transport. Self-evident, perhaps, but we have only to look at the inaccessible locations of so many businesses and services to see the extent to which this principle has been ignored.

A second key principle is reducing the physical separation of activities, in other words, reversing the spiral of mobility and dispersal. Much has been written about this. Broadly speaking, it implies mixed, accessible development within existing urban areas rather than dispersed, widely separated activities in peripheral or rural locations; it does not necessarily mean compact cities, high densities, or moratoria on development elsewhere.

A third principle is that of 'selective accessibility'. Making developments accessible on the map is not the same as making them accessible on the ground. Even short journeys by foot or bicycle may be frustrating and unpleasant, if not dangerous. A vital element of integrated land-use and transport planning at the 'micro' scale is to provide environments in which journeys by the most environmentally friendly modes are consistently the most convenient and attractive; it is these modes that should have the direct routes, priority at junctions, shortest waiting times, and, for bicycles, plentiful, secure, and convenient parking facilities. Such policies are precisely of the kind that pose a challenge to bounded rationalities.

The challenge for sustainable land-use and transport planning is to permit the values of citizens to take precedence over the immediate preferences of consumers. The priority now must be to find ways of articulating and expressing these values in the planning process.

Examples of land use policies that would result in a more sustainable transportation sector include:

- Designing urban villages characterised by "European style" development, which combines medium- and high-density housing with diverse commercial facilities in a car-free environment.

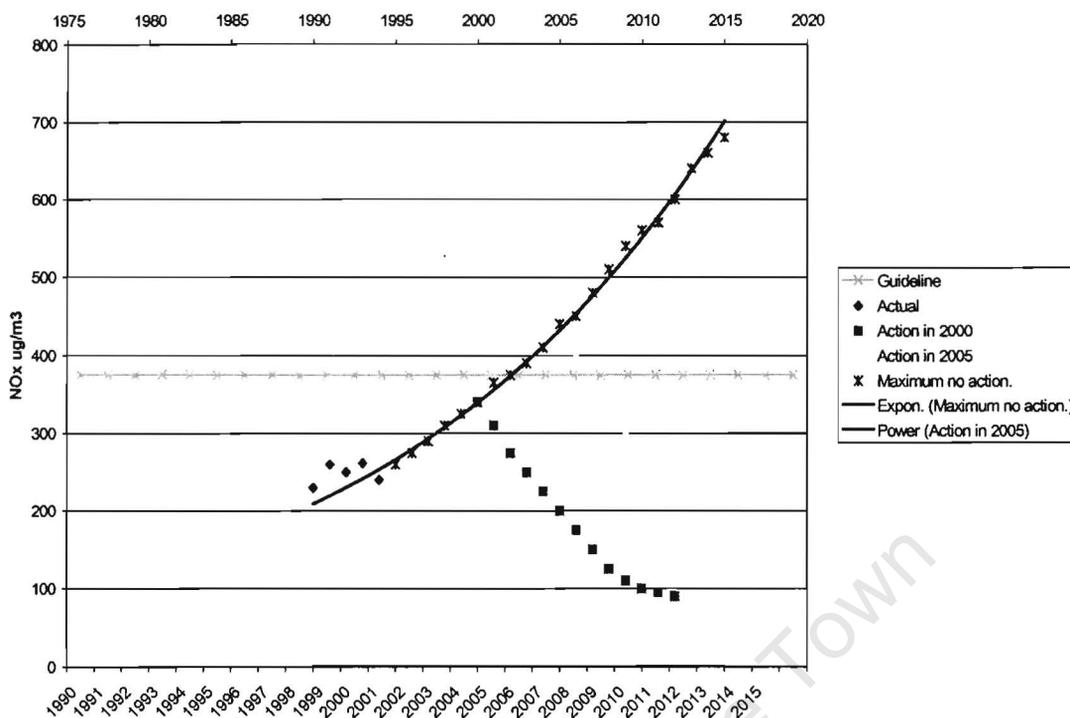
- Employing mixed-use development around transit - especially rail transit - including residential, commercial, industrial and recreational developments.
- Instituting traffic calming in urban and suburban areas to create more pedestrian- and bicycle-friendly environments.
- Reconfiguring zoning ordinances to encourage development supportive of alternative transportation modes.
- Instituting regulatory strategies, such as conservation zoning and development timing permitting, to oversee the urban development process.
- Revisiting parking requirements in urban and suburban areas. In many cases these ordinances are antiquated and require the necessary paving of parking lots.

4.3. Air pollution

The air pollution situation in South Africa is such that there are no data to prove that there is a health impact and, compared with other cities in the world, lower pollution levels are still prevailing. However, there are specific areas where the situation is approaching levels, which give cause for concern. In addition to the problems associated with gaseous emissions and concentrations, there is also great public concern with the visible pollution, the so-called "Brown Haze". Road transport is a large contributor to the air pollution problem, both in gaseous and particulate form. Whilst the various pollution levels may at the moment be below the international health limits, the present trend will result in health levels being exceeded in the near future. To give an indication of this trend and the effects that legislation might have on the problem experienced the following forecast of specifically NO_x is investigated.

The figure below shows the effect of the introduction of legislation, which would require the introduction of catalytic converters on all new cars from a specific date. This figure shows the effect of legislation introduced in the year 2000 and the alternative of introducing it in 2005. Also shown on the graph is the Guideline maximum concentration for NO_x on a yearly basis.

Figure 17 Cape Town NOx levels.¹³⁶



The results of this simplified analysis shows that if no action is taken, the level of NOx will exceed the international maximum guidelines by about 2004. If enabling legislation is adopted in 2000, the minimum levels will reach some 90% of the Guideline and will fall thereafter as the number of pre-2000 cars decreases and all new cars have catalytic converters fitted. By 2002 the NOx level has fallen to the 1995 level and by 2008 the NOx level is half that of 1995 level and by 2008 the NOx level is half that of 1995.

If legislation is delayed by 5 years, the Guideline level is exceeded for about two years before it is reduced to below the Guideline level. It will be about 2011 before the NOx levels fall to those of 1995 and it will take another 10 years to fall to half that of 1995.

From this analysis it appears that if legislation is taken by the end of the century, the levels will not increase above those recommended, but that delaying a decision past that date will result in unacceptable NOx levels.

This analysis assumes that all NO_x is produced by motor vehicles, but this is not the case with other sources being industry and commerce which contribute to the overall levels but would be unaffected by any legislation aimed at motor vehicles. A more detailed analysis is therefore required to analyse the effect of various sources and possible effects of legislation. A primary requirement for any authoritative assessment of the situation is knowledge concerning the emissions of the present and future vehicle fleet in South Africa.

Vehicle emissions in South Africa will continue to grow as vehicle ownership increases. A study done by Moving South Africa has shown that the financial barrier to buy a vehicle in South Africa is low, namely a salary of R30 000 per annum. This results in the buying of a second hand vehicle which is not well maintained which will lead to an increase in vehicle emissions in South Africa.

The measures needed to decrease CO₂ emissions parallel those aimed at cutting emissions of NO_x, except that here tackling the problem at its source implies promoting the use of economical rather than clean vehicles. Preference must of course go to the development of vehicles, which are both economical and clean, and in the area of vehicle construction issues such as enhanced passive safety must also be borne in mind. The great difference between the aims of economy and cleanliness is that there is no immediate prospect of a technical development comparable with the catalytic converter which will make cars significantly more fuel-efficient and thus significantly reduce CO₂ emissions. Nevertheless in the longer term there is scope for a range of measures, such as cutting wind and rolling resistance and recovering the energy otherwise lost in braking, which could cut energy consumption by private cars and goods vehicles, with unchanged power and weight, by perhaps 35% and 25%,¹³⁷ respectively. Such savings should be encouraged by supporting research and development and setting standards and through fiscal and financial measures. To bring about further reduction campaigns should be mounted to promote more economical driving habits, to

encourage the purchase of lighter and therefore more economical cars and to reduce car use.

Driving for economy

Speed and driving techniques have a great impact on fuel consumption and hence emissions of CO₂. Speed reductions through lower speed limits and their strict enforcement and improved driving techniques could produce a 5-10% cut in consumption. The desired driving habits can be encouraged and where necessary enforced by a range of technical measures (cruise control, speed governors, the intelligent accelerator, etc.) and the development of such devices will have to be vigorously promoted. Where practical devices already exist they may be introduced in the near future if necessary on a statutory basis (e.g. speed governors for goods vehicles if it is found that limits are not respected). South Africa is generally an importer of technology and a follower of European and American trends and therefore should establish a programme of increasingly stricter standards for vehicles and fuels.

Lighter and more economical cars

In recent years fuel savings have been achieved by advances in motor engineering, but it has been partly offset by a trend, associated with rising levels of affluence, towards heavier more powerful cars. Given the assumption that incomes and living standards will continue to rise in the long term a continuation of this trend can certainly not be excluded.

The concept of sustainable development implies, however, that trends towards "more and bigger" cannot be maintained in any field. It must be recognised that a problem of affluence is faced here. Ever larger cars are being bought because they are comfortable and confer more status. This not only increases fuel consumption in use but also raises production costs in terms of raw materials and energy. The obvious course is to reverse the current trend towards larger cars and 4X4's, encouraging a switch to lighter

vehicles, which use less energy and raw materials. The car must come to be seen simply as a means of transport.

The possibility should be examined of a levy aimed at restraining car use. Whether the annual motor-vehicle tax or the special purchase tax on private cars is the most suitable instrument for this purpose will be the subject of further consideration.

A motor car is an important symbol of wealth of its owner and of personal freedom, in South Africa especially since the change in government and the socio-political aspects around this issue and the unique situation in South Africa should receive further attention as more research in this field is embarked on.

Decreasing car use

The goal of sustainable development also implies making more economical and less polluting means of transport as attractive as possible and persuading people not to use their cars unnecessarily or in the wrong places and at the wrong times.

4.4. Congestion

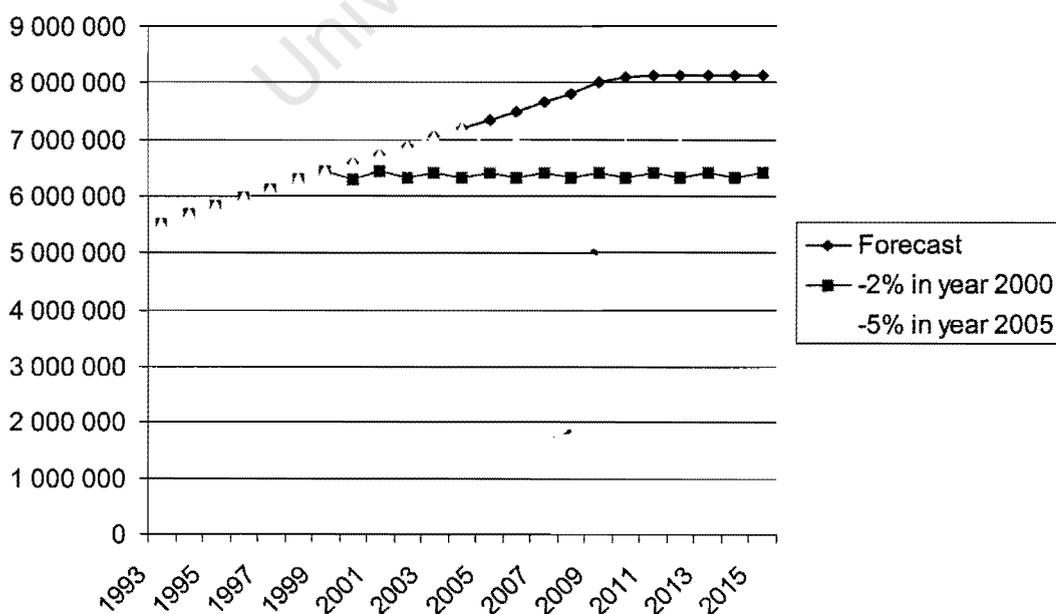
The congestion situation in South African cities compared with other cities in the world, is low. However, there are specific areas where the situation is approaching levels, which give cause for concern. In addition to the problems associated with time wasting and stress, there is also great concern with the trucks and delivery vans, which are related to the economy of the country which are stuck in traffic. Road transport is a large contributor to the congestion in South Africa problem, both in terms of the general public not using the existing rail transport option and that no other public transport options are available. Whilst the various congestion levels may at the moment be below the international levels, the present trend will result in increased stress levels and time wasting in the near future. To give an indication of this

trend and the effects that the provision of adequate public transport might have on the problem experienced the following forecast of specifically increases in congestion cost is investigated.

The figure below shows a line to indicate the growth in the car population at the same rate, which it is increasing currently. This figure then shows the effect if 2% of private car users commence to make use of public transport per year from year 2000 and then a 5% increase in the use of public transport commencing in 2005. It is assumed that government will commence with a “no regrets” option from year 2000 while in the year 2005 the new public transport system and possibly some user-charge fees will be incorporated.

The effect this will have on the congestion cost of the country is significant. The total cost in 1990 was R659 069 959¹³⁸. If 2% per year is taken off this amount which is the 1990 value to allow for new roads, the savings amount to R13 million per year for the government. If, however, in the year 2005 5% of commuters make use of public transport then the savings would amount to R32 million.

Figure 18 Car population in South Africa - forecast



Until effective instruments of restraint become available current building programmes will not suffice to shorten the tailbacks. Every effort must be made to keep economically essential traffic moving, in especially Cape Town, Pretoria and Johannesburg, and in the congested areas the best use can be made of the limited budgets by adopting a targeted approach. The first priority is to enable freight traffic to bypass hold-ups then depending on local circumstances facilities can be extended to car-sharers, buses and (in return for payment) other traffic.

Investment in the road network must therefore be geared to combining optimum use of existing capacity (particularly by the selected user groups) with some additions to capacity where this is essential. When projects are appraised particular stress should be placed on their impact on car use in relation to the target.

In the area of improved utilisation the Government should think of specifically expanded traffic-management schemes, flow-control systems, route signs which can be varied at different times of day, and separate lanes for goods vehicles, car-sharers, buses and those who are prepared to pay for shorter journey times. In the case of new roads separate-lane systems are a promising option, not least because the selective accessibility they provide helps to prevent extra capacity generating extra traffic. Studies will, however, have to be done of ways of preventing motorists from switching to less safe lower-category roads.

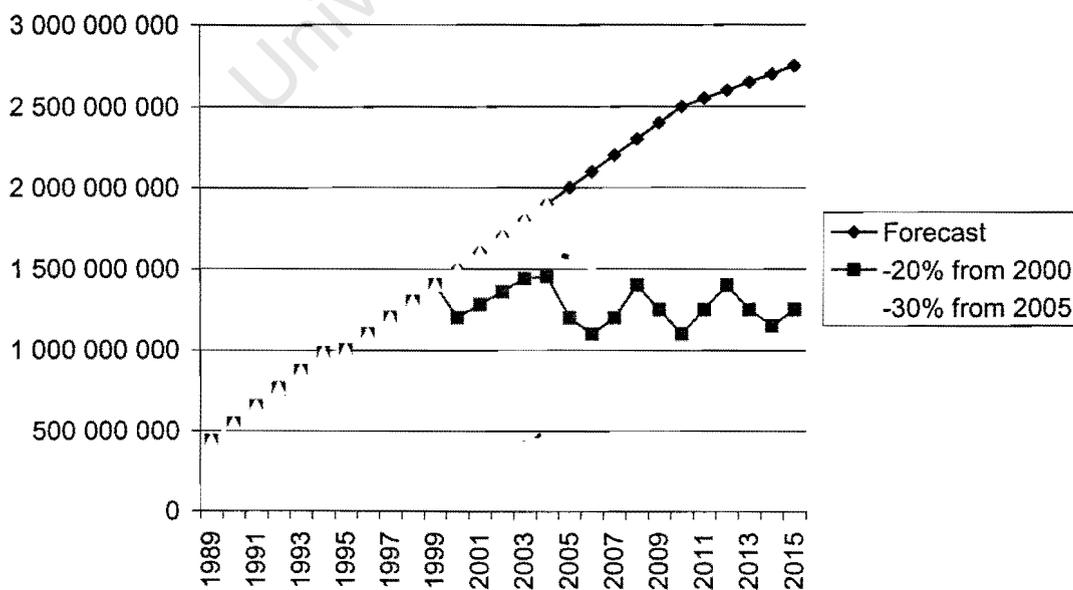
4.5. Viability of public transport

The reason for the non-viability of the public transport systems in most South African cities is the fact that it is not being used by the majority of people and also because of the poor densities in South Africa which were indicated in Figure 19. It is therefore assumed that bus subsidies will have to continue in South Africa.

However, the public transport systems need to be made more attractive and if the measures suggested be implemented then it is predicted that the bus subsidy will decrease in the year 2000 with 20% and in the year 2005 by 40%. The figure below gives an indication of the financial implication if this could be achieved. The results of this simplified analysis shows that if no action is taken, the level of bus subsidisation will increase to R3 000 million. If enabling measures are adopted in 2000, the amount will decrease to R2 400 million. If further action is taken to ensure the utilisation of the public transport system in South Africa by the year 2005 the amount that will need to be spent on subsidisation would further decrease to R1 550 million.

From this analysis it appears that if measures are introduced by the end of the century, significant savings could be achieved. This analysis assumes that bus subsidies will continue to grow at the current level, but this might not be the case. A more detailed analysis is therefore required to analyse the effect of possible effects of measures. A primary requirement for any authoritative assessment of the situation is knowledge concerning the numbers of persons travelling with public transport and why they choose this option.

Figure 19 Bus subsidy forecast



Public transport systems in all 5 the major South African cities will need investigation and ways and means to ensure that the public transport options are used need to be developed. To keep public-transport operating deficits within manageable bounds the Government should decide that fares should be adjusted in line with wage and other cost movements in the industry. However, they will not be allowed to rise more quickly than the variable costs of motoring, taking account as necessary of such qualitative factors as comfort, speed and frequency of service at peak and off-peak times. Co-operation among operators is to be promoted with a view to the further integration of charging and ticketing practices, thereby removing unnecessary obstacles to the use of public transport.

Ambitious improvements to raise the standards of the public transport system in South Africa to a much higher level with a view to carrying considerably more passengers with speed and comfort need to be undertaken. Public transport operators should be challenged to come forward with coherent plans for the industry's future, while individual cities too have to set about producing their own.

Sustainability should be the watchword, and in the case of public transport this means accelerated implementation of plans to achieve much higher performance levels. This will demand considerably higher capital outlays over the planning period. The aim is to offer a real alternative to the private car with a view to improving the quality of life, protecting the environment and enhancing road safety and this will require massive investment in both capacity and quality.

Amenity and sustainability are not the only issues involved. Urbanisation must be limited and should favour compact rather than sprawling cities. Where possible labour-intensive office developments must be located within cities. A compact city can only function with high-grade public transport: if the cities are to thrive and remain accessible in the future good public transport is essential.

The central aim of mobility policy is to maximise the percentage of commuters using public transport. All cities in South Africa need to develop public transport use policies and marketing activities. Journeys of 5-10 kilometres or more represent an obvious market for public transport, provided it is of high quality. Over the years gaps have opened up because the system has not kept pace with urban development, notably with the scale of the metropolitan regions and the growth of commuting distances. Further major residential development will be needed over the next few decades to meet the housing need. Public-transport operators must provide services whose quality (in terms of speed and comprehensiveness) is keeping with the metropolitan regions' scale and housing developments, and new concentrations of employment, should only be permitted where easy access by public transport is possible.

In the competitive battle with the private car travelling time is the main quality criterion, followed immediately by service reliability. Commuter journeys often take twice or three times as long by public transport as by car. This figure must be decreased - the aim is a ratio of not more than 1.5 for home-to-work journeys on the main commuter routes - and in the main metropolitan regions, especially Johannesburg and Pretoria metropol, total journey times by public transport between residential and employment areas must be kept as low as possible. This cannot be achieved unless there is a distinction between through (express) links within the metropolitan regions especially East Rand, West Rand, Johannesburg and Pretoria, with few stops and much higher average speeds than at present, and local (feeder) services with more stops and hence lower speeds. The number of through services in metropolitan regions will need to increase to give more direct links, which must include circumferential and tangential services (giving access to secondary centres of employment) as well as radial.

Achieving these aims will require full co-ordination between the various sectors of the public-transport system. Measures are also needed to ease the

processes of getting to the railway station (or other transport access point) and completing one's journey; this means more and better facilities for cyclists, at stops on express links within metropolitan regions as well as at suburban railway stations, easily accessible park-and-ride terminals and improved taxi services (with discounts offered to the holders of rail tickets). Employer-provided transport also offers a way of bridging the gap between main journey and final destination.

Public-transport operators and local authorities should be urged to examine the speed and the reliability of their networks. They will also need to focus on such matters as the cleanliness of vehicles and waiting areas, personal security on vehicles and at stops, information services before and during journeys and ways of reducing waiting times. South Africans are generally under the impression that it is very unsafe to use public transport. Train stations and bus stations are not maintained and they are generally crime-ridden in South Africa.

Last but not least, the charging system must meet travellers' needs in an integrated public-transport system. The Government should therefore encourage an integrated fare and ticket system. The price of travel also plays a part in people's modal choice, but fare increases are unavoidable if the public-transport system's cost to the taxpayer is to be kept within bounds. In principle fares should be adjusted in line with wage and other cost movements in the industry, but this is acceptable only if motoring costs rise at broadly the same rate. In general the aim a market-led fares policy, in which a part can be played by such qualitative factors as comfort, speed and peak/off-peak differentiation in services frequencies.

Within collective transport (a term covering private services for particular user groups as well as conventional public transport) a distinction can be made between complementary subsystems each with its own nature and function. The criteria for this functional distinction are distance between stops and speed, translating into a division between through links within metropolitan

and non-metropolitan regions and feeder services making up fine-mesh local networks. Combined forms are also possible: some types of employer-provided transport can be viewed as such. The subsystems, which together form the network of public-transport services are described separately below.

Public transport must play a greater role at metropolitan level especially Cape Town, Johannesburg and Pretoria, and to this end resources should be invested in a coherent network of rapid high-grade services provided by trains and buses.

A system of fast congestion-free, comfortable and reliable services, with long distances between stops and fed by local networks, can provide an effective alternative to car travel. To optimise services in an around the metropolitan regions it may be necessary, where traffic volumes are great, to work towards the integration of metropolitan bus and regional rail systems. Some sectors of the public-transport system, which are already heavily used may experience a considerable increase in traffic. New stations will have to be opened to serve new housing developments.

The association between land-use planning and public transport in the metropolitan regions must be stressed. The choice of new locations for residential developments and concentrations of employment must take the fullest account of transport considerations. Wherever possible such locations must be:

- in, on the edge of or in the neighbourhood of (in that order) existing urban areas, to minimise travelling distances, or
- easily capable of being tied into the metropolitan or regional public transport network, preferably with links in several directions.

This policy must apply to all metropolitan regions, with plans preferably being developed in the context of the transport regions.

In the metropolitan regions such as Midrand, Pretoria and Johannesburg, where efforts must be primarily directed at achieving a network of fast, high-grade services, the efficiency and effectiveness of the basic network must be carefully examined. The aim remains a level of service adequate for all, but considerations of cost-effectiveness demand and quality be pursued in the areas of speed, reliable time-keeping and connections and proper information for travellers; high frequency services must not be used to compensate for unreliability and lack of information.

What matters is that journeys must always be viewed in their entirety: the focus must be on door-to-door travel, since this is the car's strongest point. Taxi services traditionally do the work of the longer distance transport sector (buses and trains) - their role should be to feed the major transport links. Even aside from the association with public transport the taxi's role can be expanded if services can be made more attractive - safer, cleaner and reliable. Taxi and bus competition currently is so fierce that people are killed to protect areas of service. Taxi and bus drivers therefore need to be educated and assisted. Possibly specific medium sized midibus taxi's could be introduced. This issue is further discussed in Chapter 5.

Employer-provided transport can play a valuable role particularly in industrial districts where conventional public transport cannot compete, and initiatives in this area should be supported. Resources from tax relief for commuter travel should be channelled into a scheme for this purpose.

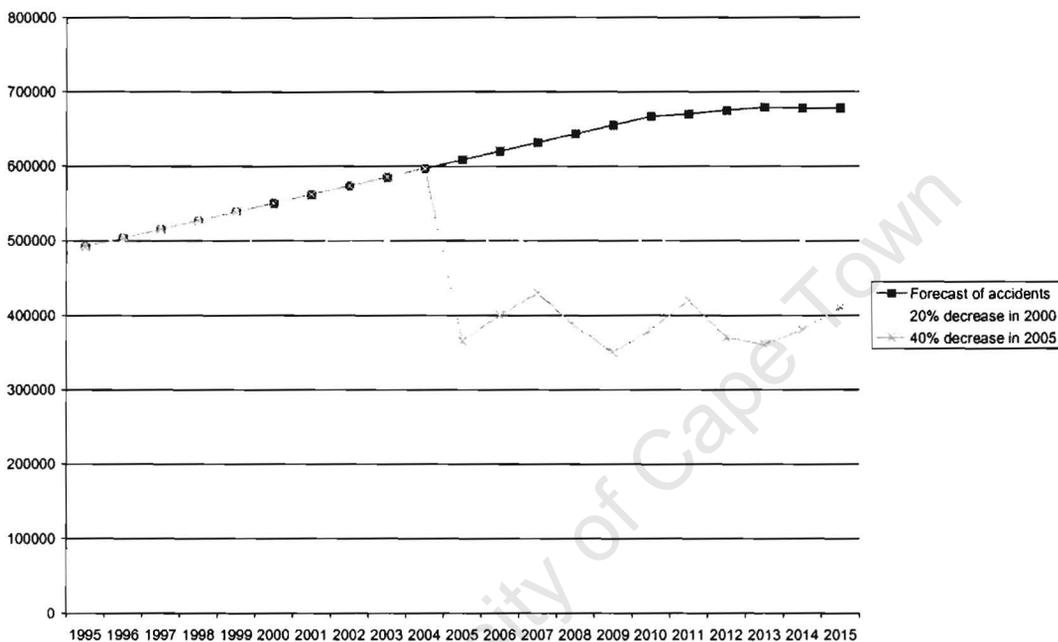
4.6. Accidents

Due to South Africans being generally ignorant of traffic laws and regulations, accidents are a major cost to the economy in South Africa.

The following graph gives an indication how many accidents will occur in South Africa if the status quo is allowed to continue. The figure indicates a number of approximately 600 000 accidents in the year 2015.

If, however, people are encouraged to make use of public transport systems by using the low cost or no cost methods described in Chapter 6 by the year 2000 a 20% decrease would amount in 175 000 less accidents in the year 2015 and if legislation and user-charges are implemented a further 100 000 accidents could be prevented.

Figure 20 Forecast of accident rates in South Africa



If the above is realised the savings will be significant as currently the total accident cost, including pedestrians is R7 532 million per year.

In the longer term intrinsic safety should be the goal. Intrinsic safety means building safety measures into the road transport system in a more structural fashion. In the past such measures have generally been taken as the need has become evident, in response to shortcomings in road design or human behaviour. For the roads a safety-centred approach must come to characterise the whole system. The concept of intrinsic safety requires the capabilities and limitations of people, vehicles and roads to be properly matched, and this in turn requires the development of safety criteria and standards for the design of infrastructure and vehicles and in education and the enforcement of traffic rules.

A hierarchical classification of roads needs to be introduced, to standardise traffic situations and homogenise traffic flows. In concrete terms this means segregating categories of road use where the disparities between them in terms of speed, size and weight are excessive. Where temporal or spatial segregation is impossible or insufficient it will be essential to narrow the speed differentials between categories of road user, there being little scope for narrowing size and weight disparities. The conceptual and physical development of such systems have is a long term matter but steps in that direction are not new: traffic-calming measures in residential and shopping areas, pedestrian precincts, 30km/h zones and the like have been in existence for some time, and significant advances have been made in vehicle safety. Such measures have proved successful. Many infrastructural measures involve reducing traffic speeds.

In South Africa the roadworthiness of vehicles need special attention. The structural incorporation of safety measures into the road transport system will not succeed unless the knowledge required is available at all levels of planning and execution. The Ministry of Transport will have to ensure that such knowledge is gathered and channelled to where it is needed, focusing initially on its own machinery. New notions such as tolls, reserved lanes for particular categories of road user and flow-control systems require focus on safety from the start. Provincial and municipal authorities will also be involved, e.g. in the framework of Transport Region plans.

Furthermore traffic offenders would have to be dealt with more strictly. If the number of accidents is decreased the money saved could be used to employ more traffic officers, which would ensure more money for each local authority.

Again the spill over effects will have a positive effect on job creation and on the financial viability of currently financial non-viable local authorities.

4.7. Conclusion

As can be seen from the above, significant savings could be achieved by implementing low cost / no cost options in the short term. By improving the public transport system, the savings could accrue more in the medium and long term. The next chapter gives concrete recommendations to commence with the solving of the transport inefficiencies in South Africa by evaluating the current drive for diesel driven medium sized buses.

Chapter 5: Possible outcomes of the taxi minibus initiative

5.1. Introduction

Government recently embarked on a project to assist the taxi minibus industry, which is on the verge of collapse. Vehicle ages range between 9 and 11 years, taxi and bus wars rage and the vehicles are petrol driven which is very expensive to operate and the engines also do not last as long as diesel engines.

The project entailed that medium sized diesel driven midibuses be made available to taxi owners at a reduced price and with the assistance of the Department of Trade and Industry to maintain the vehicles and formalise the industry.

It is important to consider the advantages it would have for the air pollution, congestion, and viability of public transport if medium sized diesel driven buses are used.

5.2. Calculation of numbers of taxi's currently operating

A good estimate of the number of vehicles introduced into the taxi market is the number of light commercial vehicles sold. Numbers of second-hand and other new models missed by this estimate are considered to be balanced by the 10% of bakkies included under light commercial vehicles. Total annual sales of these models are shown in the Table below. The most noticeable feature is the peak of just over 133 075 vehicles sold in 1996, followed by a decline to just under 102 878 vehicles in 1998. Since 1994 sales have remained stable at this low level.

Table 17 Industry vehicle sales, imports and exports¹³⁹

	1995	1996	1997	1998	1999 Projection
Domestically produced					
Local Sales	128 397	129 575	113 992	98 778	90 000
CBU Imports					
NAAMSA			362	300	350
Non NAAMSA	3 000	3 500	3 400	3 800	4 100
Total Local LCV market	131 397	133 075	117 754	102 878	94 450

If the assumption is made that no 1990 or earlier models are on the road, but that all 1994 and later models are still operating, the total number of taxis can be calculated by summing all light commercial vehicles sales since 1994. This gives an estimate of 579 554 taxis. Since the taxi is typically a high usage vehicle with a non-negligible risk of accidents during a 10-year period, it is extremely unlikely that all vehicles are still operating. Consequently the estimate of 400 000 taxis must be regarded as an upper limit.

National figures on vehicle registration for the year 1999 give a figure for Heavy Passenger vehicles (12 or more persons) at 164 665. If it is assumed that 10% of those are heavy buses and 90% are 14 to 16 seater minibuses then there are 148 000 newly registered taxis on the road. There are also a number of re-registrations at a second or further change of owner by vehicle category for the year 1999. The figure given for re-registrations is 48 000. The number of motor vehicles registered for the first time by motor vehicle category for the year 1999 amounts to 3 722. If again it is assumed that both the latter numbers consist of 10% buses then the total number of taxis on the road in South Africa would amount to: $148\,000 + 43\,000 + 3\,350$ which is equal to 194 350.

In summary, the history of new vehicle sales suggests taxi numbers of around 200 000, while the estimated number of taxis based on ages of vehicles amount to around 400 000. In this thesis a figure of 300 000 will be used as a working compromise, but wherever taxi numbers are critical to a calculation,

the sensitivity of the result to assumptions about the numbers of taxis should be kept in mind.

5.3. Effect on Air Pollution.

5.3.1. Introduction

The comparison between a petrol and diesel engine is not straightforward. In essence it can be said that a diesel car produces far more particulates than a petrol car and more NO_x than a petrol car with a catalytic converter. On the other hand a diesel vehicle produces less CO, HCs and NO_x than an equivalent petrol vehicle without a catalytic converter. There are also greater avenues for further reductions from diesel than from petrol, such as low sulphur fuel and better catalytic converters.

In most developed countries, from where the bulk of information on diesel emissions comes, three way catalytic converters are standard on most petrol vehicles as said in Chapter 2. In these countries therefore a comparison between diesel and petrol vehicles with catalytic converters and particulate traps are made, while in South Africa the comparison is between diesel and uncatalysed petrol vehicles. Diesel fares better in our current situation, but the possibility of future introduction of catalytic converters for petrol vehicles and particulate traps for diesel vehicles would change this and should be considered in decision-making.

The carcinogenic nature of the particulate matter in smoky diesel exhaust fumes is of concern. It is therefore proposed that this project must include the fitting of particulate traps to these medium sized buses to ensure that the air pollution condition in the major cities is not exacerbated. All the assumptions made in this thesis are therefore that these vehicles will be fitted with particulate traps.

5.3.2. The impact on air pollution by the project

If medium sized diesel driven buses seating 20-30 passengers are introduced in South Africa, it will not have a major impact in air pollution nationally but could have a significant impact on air pollution in the cities especially during peak hours. If this is combined with a regular maintenance programme for these vehicles it might ensure almost emission free taxis.

If all the current taxi's are replaced by diesel driven midibuses the taxi fleet will in fact be halved as these taxi's will have double the number of seats of the regular minibuses. In other words the pollution will be decreased substantially. If, however, particulate traps are not fitted to these diesel vehicles the particulate emissions will increase significantly.

In general, particulate matter (PM) is emitted in substantially larger quantities from diesel engines due to the absorbed organic compounds carried on their surface. They also make up the bulk of diesel smoke and hence have visibility and nuisance problems as well. Concentrations of PM in the size range emitted by diesel vehicles have been shown to correlate strongly with increased mortality and morbidity, apparently with no effect threshold¹⁴⁰. The importance of PM must be seen in the light of the very high background levels of PM from coal burning in townships. On one hand it can be seen as a negligible contribution to the situation, while on the other it can be seen as adding to an already dangerously high ambient PM level.

The comparative table below gives an indication of the differences in emissions from petrol and diesel vehicles* for the entire passenger vehicle fleet in South Africa. As can be seen there is no outright cleanest vehicle at present levels of technology.

Table 18 Emission factors for South Africa¹⁴¹

Coastal Exhaust Emission factors	Carburetted Petrol fleet	Fuel injected Petrol fleet	Catalytic converter	Diesel fleet
THC (g/km)	2.26	1.57	0.42	0.2

Coastal Exhaust Emission factors	Carburetted Petrol fleet	Fuel injected Petrol fleet	Catalytic converter	Diesel fleet
NOx (g/km)	3.38	2.19	0.48	1.82
CO (g/km)	15.6	15.3	3.3	1.13
CO ₂ (g/km)	216	209	267	245
Fuel consumption (l/100km)	10.5	9.1	10.6	10.5

Highveld fuel consumption and exhaust emission factors	Carburetted Petrol fleet	Fuel injected Petrol fleet	Catalytic converter
THC (g/km)	2.10	1.20	0.52
NOx (g/km)	2.12	1.89	0.66
CO (g/km)	20.2	6.4	3.8
CO ₂ (g/km)	188	190	253
Fuel consumption (l/100km)	9.9	8.7	10.5

The above figures have been calculated for the entire passenger vehicle fleet in South Africa. According to Table 8 in Chapter 3 the total passenger vehicle population in South Africa is 4 million vehicles and the number of taxi's is assumed at 300 000. That means that the taxi vehicle population amounts to 7.5 per cent of the total vehicle population. Therefore the emission factors as a result of minibus taxi's are 7.5 per cent of the above table's figures and are as follows:

Table 19 Emission factors for South Africa's taxi fleet

Coastal Exhaust Emission factors	Carburetted Petrol fleet	Fuel injected Petrol fleet	Catalytic converter	Diesel fleet
THC (g/km)	0.17	0.12	0.03	0.015
NOx (g/km)	0.25	0.16	0.04	0.14
CO (g/km)	1.17	1.15	0.25	0.085
CO ₂ (g/km)	16.2	15.7	20.03	18.38
Fuel consumption (l/100km)	0.80	0.7	0.8	0.8

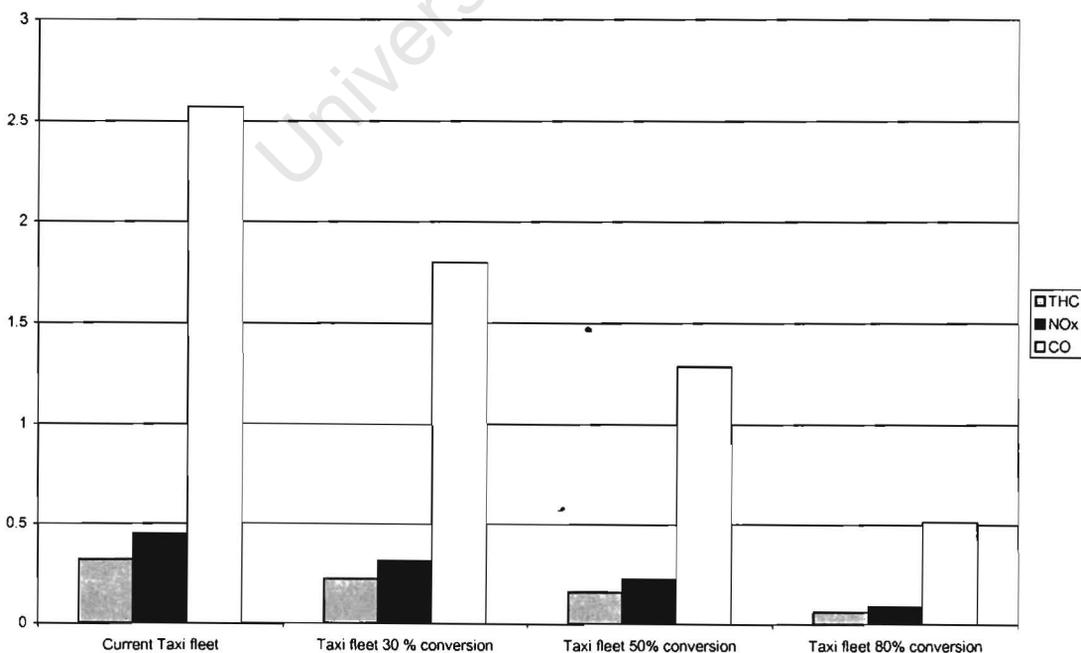
Highveld fuel consumption and exhaust emission factors	Carburetted Petrol fleet	Fuel injected Petrol fleet	Catalytic converter
THC (g/km)	0.16	0.09	0.039
NOx (g/km)	0.16	0.14	0.05

Highveld fuel consumption and exhaust emission factors	Carburetted Petrol fleet	Fuel injected Petrol fleet	Catalytic converter
CO (g/km)	1.52	0.48	0.29
CO ₂ (g/km)	14.1	14.25	19
Fuel consumption (l/100km)	0.74	0.65	0.8

The figures in the tables above indicate the lower emission factors of diesel vehicles, except for NO_x and CO₂ emissions. The graph below gives an indication that the load of all pollutants will decrease with a conversion to diesel engines. It is, however, assumed that all diesel vehicles will be fitted with particulate traps and that the particulate emissions will therefore not increase as would normally be the case.

Since the taxi's represent about 7.5% of the total vehicle fleet, the total pollutant load nationally due to petrol and diesel vehicles does not change significantly. However, it must be remembered that although changes on a national level may be insignificant, changes around taxi ranks, urban centres and along major arterial roads might be much greater.

Figure 21 The effects on petrol vehicle emissions if conversion takes place



The above graph gives an indication of the changes in air pollution if the same number of diesel medium sized taxi's remain in operation. If, however, the fleet is halved the effect would be even more pronounced.

5.3.3. Factors influencing diesel emissions

Engine Type

Diesel compression ignition engines offer better fuel economy and durability than spark ignition engines. There has been a world-wide move to diesel engines in cars and light vans based on reduced price differential and better diesel performances. Many light vehicles have turbocharged engines to increase power output. Further more direct injection and indirect injection diesel engines have different fuel use and emission characteristics. In indirect injection engines less NO_x and PM are formed, while direct injection engines are more fuel efficient¹⁴².

Engine combustion characteristics are crucial in determining emissions – in general better combustion means more complete burning of the fuel and therefore fewer particles being emitted. However, the more complete combustion also leads to greater NO_x formation – there is thus a trade-off between these two types of pollutants.

5.3.4. Conclusion

From the above it is clear that if the medium sized diesel driven taxi project is accepted and particulate traps are fitted to the vehicles, it could have a positive effect on the air pollution problems in the urban centres of South Africa.

5.4. Effect on Congestion

The effect on congestion will be significant with half the number of vehicles on the road. However, the vehicles might be slightly slower and therefore might create problems in that regard. The congestion costs will be halved, which will relieve the amount of stress suffered by passengers and drivers alike. The

bigger vehicles will be slightly less manoeuvrable than the 10 seater buses and therefore less lane switching will occur. This will also have a positive effect on all other motorists using the roads. It is anticipated that these medium sized buses will also be more comfortable with more legroom for passengers, which will also reduce stress levels if congestion do occur.

5.5. Effect on viability of public transport

Due to diesel engines lasting longer, diesel fuel being cheaper than petrol and the assistance by government for this project, passenger tariffs might decrease. The added advantage of comfort together with a decrease in tariffs might persuade more people to make use of the service.

The life expectancy for taxi petrol engines and the cost associated with the replacement thereof can be seen in the following Table.

Table 20 Prices for engine replacements (new and used)¹⁴³

USED / RECONDITIONED ENGINES		
Petrol	Cost of installed petrol engine	R4 000
	Engine life expectancy	60 000km
	Cost per year	R4 800
	Local content	0%
	Annual import bill	R4 800
Diesel	Cost of installed petrol engine	R7 500
	Engine life expectancy	80 000km
	Cost per year	R6 750
	Local content	0%
	Annual import bill	R6 750
	Extra annual cost for diesel	R1 950
NEW ENGINES		
Petrol	Cost of installed petrol engine	R12 000
	Engine life expectancy	160 000km
	Cost per year	R5 400

	Local content	100%
	Annual import bill	0%
Diesel	Cost of installed petrol engine	R20 000
	Engine life expectancy	240 000km
	Cost per year	R6 000
	Local content	0
	Annual import bill	R6 000
	Extra annual cost for diesel	R600

It is clear that although the cost of a new and used diesel engine is more expensive than a petrol engine, it lasts much longer. On the other hand the diesel engines are imported while the petrol engines are manufactured in South Africa. With the rate that the petrol price is increasing currently, it is anticipated that more and more people will buy diesel vehicles. A diesel engine plant may therefore become viable in the near future. This will have a positive effect on job creation and the economy of the country.

In calculating the typical annual fuel consumption of a taxi, a distinction must be made between urban and long-distance taxis. The following Table gives an indication of fuel consumption for a taxi.

Table 21 Estimates of petrol and diesel consumption for a single taxi¹⁴⁴

PER TAXI		
URBAN	Petrol consumption	15.18 l/100km
	Diesel consumption	10.906 l/100km
	Relative fuel saving	30%
	Distance per year	72 000
	Petrol in litres per annum	11 218
	Diesel in litres per annum	7 852
	Petrol fuel bill per annum	R39 375
	Diesel fuel bill per annum	R21 907
	Change	(R17 468)

LONG DISTANCE	Petrol consumption	11.74 l/100km
	Diesel consumption	9.979 l/km
	Relative fuel saving	15%
	Distance per year	108 000
	Petrol in litres per annum	12 679
	Diesel in litres per annum	10 777
	Petrol fuel bill per annum	R44 503
	Diesel fuel bill per annum	R30 067
	Change	(R14 436)

A comparison of fuel bills for petrol and diesel, for urban and long-distance, showed that diesel usage would already give taxis substantial savings on their operating costs. Note that the saving for urban taxis (R17 468) is substantially larger than that for long distance taxis (R14 436) due to the greater relative economy of diesel in town.

Based on the proportion of long distance taxis (25%), an estimate of the fuel bill saving to an "average" taxi from using diesel was calculated. With current pump prices this is approximately R9 000 per annum. Using these consumption estimates for individual vehicles along with the total number of taxis (300 000), the amounts of fuel used in the taxi industry can be calculated. The left column is the present situation in which all taxis use petrol. The right column shows the figures for total conversion of the existing fleet to diesel.

Taxi fleet totals	All petrol	All diesel
Taxi petrol consumption	7169 MI	0
Taxi diesel consumption	0	5588 MI
Petrol substituted	0 MI	7169 MI
Taxi Petrol Bill	R25 billion	R0
Taxi Diesel Bill	R0	R15 billion
Saving on fuel bill	R0	R10 billion
Total annual fuel bill	R25 billion	R15 billion

With existing pump prices, the industry would save R10 billion on its annual fuel bill of R25 billion. These savings must, however, be set against the capital outlay of converting to diesel as well as any differences in the annualised costs of running a diesel engine.

It is clear that the viability of the taxi industry will increase if this project is accepted.

5.7. Conclusion

It would seem that of the different options, diesel offers the most realistic and sustainable way of improving the economics of the taxi industry. Conversion to diesel could probably be achieved quite rapidly through a balance of pump-pricing and supply-side measures in the motor industry. The latter are the most important, since the current barriers to diesel usage are to be found in the motor industry. These measures could take the form of reduced VAT or a taxi vehicle incentive scheme for diesel midibuses.

The conversion may be fairly rapid as the taxi fleet is old. High prices and a lack of finance have been depressing new taxi vehicle sales to around 99 078 (this figure includes commercial vehicles, bakkies and minibuses) in 1998 and is 13.4% less than the previous year. A combination of reduced price vehicles and improved access to finance could lead to dramatic increases in the numbers of new vehicles entering the industry. Without any changes in the taxi industry, taxi numbers will probably decline quite rapidly. This would impact negatively on commuters unless service levels from other forms of public transport are greatly improved.

Taxi conversion to diesel should be accompanied by a diesel engine maintenance programme supported by government, as well as particulate traps for all South African diesel vehicles.

Overall the conversion to diesel driven medium sized taxi's will have a positive effect on the air pollution, congestion and viability of public transport in South Africa.

The following Chapter takes into consideration all the previous Chapters and give definitive recommendations to ensure a sustainable transport system in South Africa's urban centres.

University of Cape Town

Chapter 6: Recommendations

6.1. Introduction

The 5 major cities in South Africa face all the transportation challenges of large modern metropolises: congestion, air and noise pollution, accidents, among others. These challenges are compounded by a growth rate in automobile ownership, subsequent changes in travel choice from buses to automobiles, continuous low-density urban outgrowth and increases in total trip distances, and a sustained growth in the total number of motorised trips within the cities. In an attempt to better understand the current transportation situation in South African cities this thesis has aimed to establish a framework within which its various impacts - personal expenditures, environmental consequences and social effects - can be measured. The intention of the analysis is to establish a baseline by which future system performance can be measured as well as to assist in evaluating various policy, infrastructure, and technology options.

What is clear is that uncontrolled growth in private car ownership needs to be curbed in order to meet the goals of sustainability in transport in South Africa.

6.2. Policy levers available

The Growth Equity And Redistribution (GEAR) strategy of the government in South Africa aims to create 400 000 new jobs per annum for the next 3 years. General policing of transport issues could act as a policy lever to create jobs for more human resources to monitor air pollution, to control vehicle emissions and to enforce current legislation for vehicle emissions, driver behaviour to decrease accidents and congestion control.

The Department of Transport in South Africa is also in the process of establishing new policies and the White Paper for the Department stresses the fact that South Africa needs an efficient, affordable transport infrastructure for all. Research is already being done to determine which transport facilities would satisfy the needs of South Africans the best.

The previously disadvantaged groups are now isolated in order to provide services for them as a priority. Unfortunately this is not done in an integrated way (e.g. houses provided without thinking about the transportation issues). If done correctly, this could also be the opportunity to change the minds of people aspiring to have an own private vehicle. The general behaviour of people will have to be changed in order to reduce urban air pollution.

To indicate the seriousness about achieving sustainable transportation, policies are needed that will impose the true costs of transportation on different modes, bring to market technologies that reduce transportation impacts, and provide information for people to make better choices. Incentives need to be changed, facing individuals and thereby individual behaviour so that entire communities will demand transportation and land use improvements. Clearly, the most effective policies are those that affect all three visions of sustainability.

The issue of sustainable transport represents a challenge for the political process. A number of broad policy areas are involved: economic; social; environmental; and fiscal. Demand management means some restrictions - and applying restrictions to well-established and entrenched behaviour across the population is a daunting exercise at any time. Increases in transport costs for better environmental protection raise arguments about improving international competitiveness and balancing those arguments with responsibilities for the general health of the nation's citizens and the well-being of future generations will call for lateral thinking. In short, managing the process will demand political skills of the highest order.

Given that the directions and aims of policy are clearly agreed, there is no guarantee of success in implementation. Even with a vision of the end objective the transition will be testing, because, at root, there is a clash of freedoms - and clashes of freedoms are the very essence of political and social conflict.

Particularly in the heat of the argument, freedoms are liable to be seen as absolutes. That is rarely the case. Freedom can be abused, misused, or taken to unacceptable extremes. However, there has to be limits.

In the twentieth century, freedom of mobility has become an issue. The citizens of the end of the Victorian era could hardly have imagined what is taken for granted today, namely, the opportunities there are for travel nationally and internationally. The right of the motorist to take his car when and where he likes has become so established that it would not be surprising to see it as a candidate in some people's minds for inclusion in any bill of rights. The Daily Telegraph of 19 October 1994 summed up its comments on the debate by saying: "for all its undoubted disadvantages, the car confers a freedom of movement that most people take for granted. In future that may well have to be moderated, but it cannot be taken away. Freedom of mobility has undoubtedly made our quality of life better. But, taken to extremes, it clashes with another freedom - the right to enjoy a reasonable environment in which to live."

The environmental case too can be taken to extremes and the argument misused. Practically any industrial development involves some detrimental impact on some part of the environment. Extremes of unthinking environmental protection would mean surrender of economic development and progress. That might be acceptable to those who are fortunate enough to lead comfortable lives today but is in no way acceptable to those who are further down the chain of prosperity, let alone those who suffer poverty and deprivation.

Thus, for South Africa at the end of the twentieth century, the question of transport and the environment comes down to a balance between the freedoms the two represent. For sustainable development in transport what is needed is the protection of mobility without the environmental damage and distress that misuse of that freedom can cause.

South Africa is in the unique and even advantageous position that out of a car population of 5 million, 2 million is owned by the previously advantaged and the majority of the population is currently still travelling by train, taxi and bus. Efforts will have to be increased in order to make these modes more attractive.

Investment needs to be maintained. If the balance of spending between the different modes is going to meet the requirements of a sustainable system, then one way or another, wider economic and social costs and benefits need to be reflected in the investment decisions across the transport sector. The fact that the present problems of pollution and congestion exist suggests that it has not been managed effectively or at all.

In general, these wider issues of pricing and investment seem to be more effectively handled at local level. At that level, the transport problems and opportunities can more readily be seen in the round. The total journey requirements- from start to finish- of different groups in the traffic mix can be identified and provision can be made for the most appropriate combination of transport modes to meet the total needs. The different modes can be used where their strengths will contribute most. That is valuable not just for the opportunities it can bring for the public transport operators but also for the welfare of the communities involved.

As a key part of the framework of policies needed, the effective devolution of decision-making on local transport needs to local bodies, together with the necessary funding and training. In South Africa the local authorities are currently in a financial crisis, but to solve this problem proper planning, and budgeting will have to be done. The Integrated Development Plans done by local government must include the local transport needs.

6.3. Behaviour and Education Policies

Changing people's attitudes and the way they use transportation may require behavioural and educational policies. These policies include:

- Increasing the distribution of information re. environmentally friendliness of vehicles to new vehicle purchasers and including emissions information for cleaner models.
- Launching country-wide promotional campaigns for transit and high occupancy-vehicle programmes, advertising the benefits of such behavioural changes to the public.
- Using the media to encourage shifts in travel behaviour. TV can educate an entire community about socially beneficial transportation options and provide moral suasion that leads to behaviour changes.
- Providing training for the general public on techniques to reduce motor vehicle emissions, energy use, and accidents, as well as training on safe bicycling techniques.
- Educating children before they are old enough to use a car. Materials on the societal impacts of transportation choices can be incorporated into primary and secondary school curriculum's in programmes.

6.4. Past achievements and new objectives

For transport to be a driving force for economic growth and social development, it must be efficient and effective and meet the needs and demands of all transport customers, within the present constraints on our resources.

This was one of the many conclusions of the Department of Transport drawn from the consultative process in developing a White Paper on National Transport Policy, which, as a major policy review, was one of the first tasks undertaken by the Minister of Transport in South Africa. At the end the Department of Transport made a commitment to develop specific goals and strategies for South Africa's transport system for the future through a project

which was called Vision 2020. This was done to develop an overarching long-term strategy to implement objectives set out in the White Paper.

Vision 2020 has now been renamed Moving South Africa, and represents a R20 million investment by the Department of Transport in a committed endeavour to deliver their vision. Together with the work on institutional reform and spatial development initiatives, it forms part of the aim to be globally competitive, to ensure economic growth and the meeting of basic needs in transport. To accomplish this an integrated transport system is needed.

An integrated transport policy involves regulation and restraint of many kinds: pricing measures, special lanes for shared cars, parking restrictions and speed limits are just a few instances of measures which cannot achieve their goals unless people observe the rules. Regrettably such compliance cannot be assumed: parking regulations are flouted on a massive scale and speed limits widely ignored.

The guiding principle must be that in terms of their purpose and operation rules are so clear and comprehensible that compliance is seen as natural and proper; public information programmes on the measures to be taken are therefore essential. Where desired behavioural changes conflict with individuals' immediate interests, however, such programmes cannot work in isolation but must form part of a balanced mix of measures aimed at ensuring that policies achieve their objectives.

There are many situations in which individuals, while understanding the purpose of some regulation, nevertheless seek to evade it. There are in principle three ways of tackling this problem:

- preventative measures, in the form of physical or technical restraints of some kind;
- deterrent measures, involving surveillance and, where regulations are breached, sanctions;

- administrative measures involving the comparison of different sets of records (taxation records, vehicle test records, insurance records)
- educational measures, teaching road users defensive driving techniques and the advantages of maintaining a vehicle.

6.5. Possible policies for the year 2005 and beyond

Economists advocate two related measures to avoid policy mistakes. The first is the cost/benefit test, which requires that policies produce benefits exceeding the costs. Cost/benefit analysis can help answer the questions of whether an option should be attempted at all and when to stop it. The second test is one of cost-effectiveness, which is a measure of the relative costs of achieving a given goal by different means. Cost-effectiveness suggests where society's scarce physical, intellectual, and financial resources can be conserved by substituting a less expensive means of achieving the social goal. Cost-effectiveness can help answer the question, Should this goal be achieved by a different set of policies? Studies of the efficiency of existing regulatory policies to control externalities have consistently found that regulations have been poorly designed, resulting in costs of control that far exceed the estimated cost of efficient policies.¹⁴⁵ Frequently the cost also exceeds the estimated benefits by a wide margin.

How far should environmental considerations be pushed when it comes to increasing fuel economy? At any given time and under any given regulatory structure, environmental benefits can be increased. However, costs to do so mount at an increasing rate. Additionally, as costs rise for smaller true additional environmental benefits, there is increasing disagreement from industry with the incremental moves to greater environmental control. Over time, however, technical progress will improve these trade-offs, resulting in lower and flatter cost curves.

There are two main ways in which government and industry co-operation can address the trade-offs that limit achievement of conservation goals. The first is dynamic government/industry co-operation in research to facilitate the

technical advances that lower the future cost of achieving any given level of environmental benefit. An accelerated rate of technical progress means that greater fuel economy is possible while continuing to improve other vehicular characteristics that are valued by consumers. Because there is progress over time, the trade-offs among vehicle characteristics will always look better. Looking backward, it should be no surprise that both fuel economy and vehicle safety have improved over the last decades. However, this result in no way invalidates the fundamental insight that at any point in time these two vehicle characteristics are traded off. On the margin, improving one must reduce the ability to improve the other.

South Africa, however, allow the import of vehicles that no longer meet the European standards and also have no maintenance schemes implemented. This is therefore an area where the same intervention could prove to be very significant – e.g. enforcing legislation, phasing out of leaded petrol and providing standards for the vehicle manufacturing industry to ensure fuel efficiency and air pollution controls.

The second critical area for government/industry co-operation is policy design. Moving to a less costly regulatory structure can essentially shift society to a lower-cost path to achieve the desired level of environmental benefits. Failure to co-operate has an opportunity cost that is real, but not always obvious. Movement to a lower cost curve is the “opportunity” presented by government/industry co-operation when comprehensive market-based policies result; however, such an effect is difficult to achieve in practice. Although industry overall has much to gain from a general move to an efficient policy framework, the reality of the political decision-making process is that often more is to be gained or lost by shifting the burden to some other sector.

Due to South Africa’s unique situation it is important that the previously disadvantaged must be taken into consideration. Transport costs to them are high as it is and therefore these costs need to be lowered. Furthermore the

system need to be made more attractive, reliable and efficient as encouragement to commuters to remain with their choice of public transport.

The taxi minibus industry must be assisted by government to formalise, to get more comfortable medium sized diesel vehicles which will last longer and to assist them with information dissemination regarding time tables and routes. Proper consultation therefore is imperative for the taxi owners to understand the benefits of the project as well as to accept it.

If people are satisfied with their travel arrangements they will refrain from investigating other options e.g. buying a car.

Overall transport policy should consist of an optimal mix of different types of instruments: negative and positive economic incentives, command and control instruments (such as regulatory standards), moral suasion, information, etc. Existing standards and regulations must be enforced effectively. Adding finely tuned economic instruments to laws that are routinely ignored (e.g. in regard to road safety) make no sense where the existing legislation should in theory have the most significant effects. Introducing instruments that cannot be enforced effectively is similarly counterproductive.

The following criteria must be considered in the development of policy options:

- effectiveness in achieving the main objectives of efficiency and fairness;
- low costs for administration and high level of compliance;
- distributional equity (among social groups, regions, countries)
- transparency;
- few, or insignificant negative side effects;
- synergy with existing instruments and continuity with existing frameworks;
- legal compatibility and related political acceptability;
- time-frame for implementation.

Based on detailed analysis of individual cost components in chapter 4, an optimal mix of instruments must be determined. This mix should:

- contain economic as well as command and control instruments, plus traffic management and infrastructure development elements;
- be differentiated between rural and urban areas, and between short and long time horizons;
- be adaptive to technological progress, in particular in metering and monitoring technologies;
- include adequate enforcement of regulations.

Command and control instruments, in particular technical standards, continue to play an important role. They are necessary in the fields of safety of roads and vehicles, speed management regimes, minimum noise standards, air pollution emissions standards, etc. For specific urban policies, parking management systems will be an additional policy element. Voluntary agreements between governments and industry should receive increased attention.

In the short term conventional tolls on certain access roads, bridges and tunnels in and around major cities of South Africa could be used, thus achieving some measure of control of traffic volumes in congested areas. In the process an examination should be made of the feasibility, from the start or at a later stage, of electronic charging.

Tolls can have the adverse side-effect of displacing traffic to lower-category roads, creating "rat runs" with the added danger that this entails (more accidents). Where traffic is displaced in this way the most effective solution must be sought in the light of local circumstances.

6.6. Recommendations

6.6.1. Who should be involved

The goal of a sustainable society with a transport system geared to its needs will not be easy to achieve; on the contrary, it will require unprecedented endeavours.

Government cannot carry the responsibility alone. The co-operation is needed of everyone involved in making decisions on transport; every individual, every company, every local authority will have to take responsibility for their part in the task of achieving a sustainable society. A new division of functions is needed between the Ministry of Transport, local government, industry and relevant organisations in society.

If these ambitions are to be achieved action will be needed at various levels: Southern Africa, metropolitan regions, rural areas, industry, social organisations and the public.

6.6.2. Short term solutions

The petrol/diesel tax differential.

As diesel consumption in South Africa has a close correlation with the GDP of the country it is clear that diesel is mainly used for economical activities. It is therefore recommended that the differential between petrol and diesel should increase significantly. This will ensure economic growth and a balanced consumption of petrol and diesel. This will also assist South African industry to become more internationally competitive.

Assistance to the minibus taxi industry

The minibus taxi industry is on the verge of collapse as the vehicles are generally very old (10-12 years) and new minibuses are not being manufactured any longer. The recommendation is that assistance must be given to this industry as they are very important in the transportation of people in South Africa. It is recommended that serious consultation takes place to ensure that diesel medium sized buses are acceptable to them, and that the

benefits of the project are understood. Assistance is also necessary with regard to formalisation, publication of routes and areas of operation. Education and training regarding defensive driving techniques will also assist to decrease accidents.

Phasing out of leaded petrol

In order to ensure that air pollution does not become worse in South Africa, it is important that legislation to phase out leaded petrol be introduced as soon as possible. This is important as catalytic converters are rendered ineffective if leaded petrol is used by such a vehicle and this will make air pollution worse. This will also assist South Africa to become more internationally competitive as vehicles manufactured in South Africa should be according to international fuel efficiency and pollution standards. Vehicles could then be exported, and the manufacturing industry could expand.

Catalytic converters

Catalytic converters must be made mandatory to all new vehicles in South Africa from the year 2002 onwards. This will ensure that air pollution will decrease. Combined with this, an effort to scrap old vehicles should be investigated.

Town and regional planning

The ministries concerned should reach agreements on location policy for residential and industrial development. Co-operation within the new regions is a precondition for success at the level of the metropolitan regions. Important measures aimed at restraining car use (and in particular car-borne commuting) will need to be taken at regional level. The improvement of road safety is also a task for the municipalities. Coherent approaches need to be developed in rural areas which co-ordinate transport policy with policy on the location of homes, workplaces and recreational and other public facilities. Transport regions should also be established for the more rural parts of the country, preferably in conjunction with the regional development plans referred to in the Development Facilitation Act.

Information to and education of end users

Social organisations - voluntary organisations, political parties and the like must help form a bridge between government and people. Their co-operation is essential in ensuring a broad base of public understanding and support for the measures implied by a sustainable transport policy. Major changes will be needed in public behaviour and attitudes. The car, now often seen as a symbol of status and individual freedom, is set to lose some of its attractions and advantages. In addition an appeal is to be made to the public's sense of responsibility as people are asked to tailor their actions to higher values as the maintenance of a decent environment.

Safeguarding rail services

It is very important that stations and trains become more user friendly and safer. People in South Africa currently pay more to travel by minibus taxi rather than commuting by train due to the feelings of insecurity at the stations and in the trains. The stations and trains are also not well maintained. Government should increase its investment into this area of transportation as it could be very effective and efficient if well managed.

Special housing programmes

Special housing programmes should include moving those people that travel more than 2 hours to work every day to city centres. Mixed areas where residential and industrial areas are integrated are possible. Flats could be build on or beside work places. Large industrial employers should also investigate the housing of employees and endeavour to assist them as far as possible in obtaining a house or place to live close to the workplace. This will also have a positive effect on production.

Enforcement of traffic regulations and the Air Pollution Act

It is important that problems are tackled at their source and therefore it is necessary to start investigating the setting of emission standards and enforcing the existing legislation. Maximum speeds, safety requirements and

technical measures affecting driving behaviour and speed must be enforced to ensure that the rate of accidents decrease.

Emission testing equipment

Emission testing equipment is at an advanced stage of development in Europe and the US. Samples of these equipment could be imported to South Africa and adjusted to suit the South African requirements as the road side measurement of vehicle emissions is a major barrier for the enforcement of existing legislation. This will also create more jobs and therefore have a positive effect on the economy and the air quality of the country in the long run.

6.6.3. Medium term solutions

High speed rail

Central Government has responsibilities relating to investment in the national rail network and metropolitan transport, the control of operating deficits and the early improvement of collective-transport provision inter alia through the promotion of employer-provided transport. Central Government's tasks include improving accessibility on the trunk-road network and making special provision for specific categories of road-user. Industry has a vital interest in high standards of accessibility and safe and efficient transport for its workers, but congestion due to the vast scale of car-borne commuting is making access more and more difficult while sickness absence as a result of road accidents is a major business cost. It is thus in the industry's own interest to help reduce car-use for commuting purposes.

Retrofitting of catalytic converters and particulate traps

It is understandable that not all old vehicles could be retrofitted with catalytic converters and particulate traps, but a significant number of vehicles could be targeted as a start. Government vehicles which are all stored in the same place and regularly serviced by the same people could easily be retrofitted. Government will then also set the example for other industries to follow. It is also believed that buses, trucks and diesel bakkies of local government could

be targeted for particulate traps as the same applies to these vehicles. It is believed that this will already make a significant impact on air pollution in South Africa.

6.6.4. Long term options

Further investigation into the externality costs of transport need to be investigated as well as the fiscal and social issues related to it. By doing this the value of public transport will be shown and more will be done to ensure that city centres are kept free of private cars and a variety of public transport options are available which are efficient, punctual, safe and affordable for all.

Alternative fuels

Alternative fuels and technologies are at a relatively advanced stage in development in South Africa. Battery vehicles have operated in South Africa since the 1960's. Now that natural gas has been discovered in South African waters the possibility of compressed natural gas fuels should be investigated. Alternative technologies for example the hybrid and series hybrid engines could also be considered as the technologies have already been developed elsewhere in the world.

6.7. Conclusion

The time-scale of such measures is necessarily very long, with a gap of ten years or more between preparation and completion. This does not mean that results cannot be achieved in the short term: on the contrary, in the area of incentives and support they can come quickly. In the area of improvement of public transport and environmental amenity too could be done in the short term. The process is not to be left to chance. Government should understand that the chances of long-term success depend in a significant measure on the results achieved in the short term and every effort will therefore have to be made to plan a number of key targets. Implementation should be regularly monitored through the Moving South Africa plan, pinpointing the fruits of policy year by year.

It should be realised that South Africa is in a fortunate position as currently only 5 million vehicles exist in a country with a population of 40 million. The challenge that South Africa is facing is to keep the people on the public transport system by improving it and making it safer and more convenient. This is a window of opportunity which may not exist for long, and which should be seized in the short term.

Finally, a comment made by the Steering Group in the Ministry of Transport that, 30 years ago, oversaw the production of the report "Traffic in Towns". This comment ¹⁴⁶ graphically describes the challenge that we will face today - how to gain the benefits, while avoiding the adverse impacts, of the motor vehicle:

"We are nourishing at immense cost a monster of great potential destructiveness. And yet we love him dearly. Regarded in its collective aspect as 'the traffic problem', the motor car is clearly a menace which can spoil our civilisation. But translated into terms of the particular vehicle that stands in our garage or outside our door, we regard it as one of our most treasured possessions of life, an instrument of emancipation, a symbol of the modern age. To refuse to accept the challenge it presents would be an act of defeatism."

South Africa does not have public acceptance of this dilemma but the challenge must be accepted and the public acceptance must be cultivated. People want the benefits of the motor vehicle, but they also want to sustain the quality of their lives and the quality of the countryside. Strategic traffic management offers the means of reconciling these two desires. Wider programmes of public information and education will be needed. But the new realism has arrived and is gaining wider acceptance among the people and within Government.

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