

# **Air Pollution and Climate Change Co-benefit Opportunities in the Road Transportation Sector in Durban, South Africa**

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## **Abstract**

The contribution of the road transportation sector to emissions of air pollutants and greenhouse gases is a growing concern in developing countries. Emission control measures implemented within this sector can have varying counteracting influences. In the city of Durban, South Africa, the growing dependence on privately-owned motor vehicles and increasing usage of roads for freight transport have all resulted in significant air pollution and greenhouse gas emissions. In this paper, an emissions inventory was developed for the road transport sector and was used as a basis to explore intervention opportunities that are likely to reduce simultaneously, air pollution and greenhouse gas emissions in this sector. It was found that reducing the vehicle kilometres travelled by privately-owned motor vehicles and improving the efficiency of road freight transport offered the greatest potential for achieving co-benefits.

*Keywords: road transport; air quality; greenhouse gas emissions; South Africa*

## **1. Introduction**

Globally, the transportation sector is estimated to contribute about 25% of carbon dioxide (CO<sub>2</sub>) emissions, with the road transport sector responsible for 80% (WRI, 2007). Emissions to the atmosphere are determined by the quantity of fossil fuel consumed by the vehicle, vehicle technology, fuel quality and transportation land-use planning (Soylu, 2007). Research shows that measures implemented to control emissions from this sector, may result in unintended secondary impacts. Emissions of both greenhouse gases (GHGs) and traditional air pollutants

make the road transport sector a suitable choice for investigating opportunities for implementing a co-benefits approach to tackling air quality management (AQM) and climate change mitigation.

The co-benefits approach is based on the principle of co-control of atmospheric emissions to yield simultaneous benefits for climate change and air quality. The co-benefits approach in road transport has been applied in cities such as Bogota (Woodcock *et al.*, 2007), London (Beever and Carslaw, 2005) and Mexico City (McKinley *et al.*, 2005) and has successfully demonstrated the multiple environmental and social benefits of atmospheric emission reductions in the road transportation sector.

The co-benefits approach to AQM and climate change mitigation in this sector is of particular relevance to developing countries as they often face numerous air quality challenges and are also considered the fastest-growing source of GHG emissions (Gan, 2003). Many countries in Africa are typically characterised by poor road transport infrastructure and aging motor vehicle fleets that are poorly maintained, both of which contribute to increased emissions (Zachariadis *et al.*, 2001).

Surprisingly, there has been little emphasis on co-benefits research for the road transportation sector in Africa. South Africa, which represents the largest economy in Africa, has in recent years made significant strides toward investigating and understanding the opportunities for GHG mitigation in the country (SBT, 2007), paving the way for prospects to develop innovative GHG emission reduction strategies. However, there has been no consideration of GHG emissions within a co-benefits framework, with opportunities for co-control of emissions and the simultaneous reduction of air pollution and GHGs.

The purpose of this paper is to determine the contribution of the road transportation sector to GHG and air pollutant emissions in Durban and to investigate opportunities for co-control of emissions. Section 2 of this paper provides a description of legislation and policies related to road transportation emissions in South Africa. Section 3 details the development of the road transportation emissions inventory for Durban. Options to simultaneously reduce air pollution and GHG emissions from this sector are discussed in Section 4, together with estimates of the emission reductions that potentially can be achieved. Section 5, provides some key recommendations for implementing a more integrative approach to managing atmospheric emissions within this sector.

## **2. Overview of legislation and policies addressing road transportation emissions in South Africa**

The transport sector is dominated by the use of liquid fuels that are heavily dependent on the import of crude oil (Vanderschuren *et al.*, 2008). This sector contributes ~9% to South Africa's total GHG emissions (SA, 2009). The road transport sector, which is responsible for 88% of the national transport sector energy demand (Haw and Hughes, 2007) is therefore the largest contributor to GHG emissions in the sector. From an air pollution perspective, Wicking-Baird *et al.* (1997) and Scorgie *et al.* (2004) have identified road transport in major South African cities such as Cape Town, Johannesburg and Durban as contributing significantly to carbon monoxide (CO), nitrogen oxides (NO<sub>x</sub>) and particulate matter (PM) emissions.

In response, the South African government has implemented measures to reduce harmful motor vehicle emissions. Certain constituents of fuels such as lead and sulphur are known to have adverse health effects and to be incompatible with vehicle pollution control technologies. The phasing out of lead-based petrol began in 1996, with lead being completely phased out by 2006. The phasing out of lead-based fuels has had two important outcomes in South Africa; the first is linked to its direct reduced impact on human health, and the second is that it has allowed the introduction of catalytic converters which control vehicle emissions (Stead and Molden, 2009).

In terms of Section 23 of the National Environmental Management: Air Quality Act (*Act No.39 of 2004*) (the AQA), vehicles can be declared as controlled emitters if they are likely to impact on the environment and health, and vehicle emission standards will be developed. An implementation strategy for the control of exhaust emissions from road-going vehicles was gazetted in 2003 (SA, 2003), thus allowing for motor vehicles to be considered as controlled emitters under the AQA. The overall approach used in this strategy was based on the example of European standards for vehicle exhaust emissions and fuel specifications as shown in Table 1, which also describes the present and future vehicle emissions standards as currently implemented and proposed for motor vehicles in South Africa.

The first phase of this strategy required that both diesel and petrol be manufactured with an upper sulphur limit of 500 ppm, with an option for a low sulphur grade diesel containing 50 ppm sulphur. The reduction in the sulphur content of petroleum products enabled the use of vehicles with advanced vehicle technologies, such that in January 2006 all newly manufactured vehicles sold in South Africa were required to conform to Euro 2 and Euro II emission

standards. The overall aim of the strategy is to ensure that all newly manufactured vehicles comply with Euro 4 and Euro IV standards by January 2012 (SA, 2003).

**Table 1: Fuel specifications for South Africa and Europe (Adapted from SA, 2003)**

	Unit	2006	2008	2010+	Euro 2	Euro 4
<b>Petrol</b>						
Reid vapour pressure	kPa	65		undetermined	70	
Benzene	% by volume	3	3	undetermined	5	
Maximum Sulphur	ppm	500	500	50	0.05 % by mass	50
<b>Diesel</b>						
Sulphur	ppm	500	500 and 50	50		

### 3. Case study of Durban

Durban has a population of over 3.5 million and a passenger car ownership that is above the national norms, at 189 per 1000 population. A recent household travel survey highlighted the dependence of passenger travel on motor vehicles. The presence of the Durban port, manufacturing industries and the Durban International Airport further contribute to high traffic volumes of slow-moving heavy vehicles on the roads.

An air quality management plan (AQMP) has been developed for Durban (EM, 2007a). Though primarily focused on interventions within the industrial sector, the AQMP does recognise that road transport is a significant source of air pollution. Continuous air quality monitoring undertaken by the municipality as part of its AQMP suggests that there is a growing contribution of vehicular traffic to air pollution in certain parts of the municipality, including areas along major freeways and the Durban city centre (EHD, 2007; 2008), with frequent exceedances of PM and NO<sub>x</sub> ambient air quality standards reported. Additionally, road transport is considered to contribute to over 25 % of Durban's total GHG emissions (EM, 2006).

Durban has taken some steps to reduce congestion that include the introduction of a bus lane on a major freeway, the widening of heavily congested roads, and the construction of flyovers. Other efforts have directly targeted improvements to public transport with indirect opportunities for reducing atmospheric emissions. These include the nationally run taxi-recapitalisation programme and the 'Durban people mover', an initiative targeted at transporting tourists around the city.

Durban is representative of major national trends in the road transport sector and as such can be used as a case study to investigate options for achieving co-benefits within a South African context. The following section details the development of an emissions inventory.

### **3.1 Methodology**

#### **3.1.1 Emission factors and the COPERT model**

Wong and Dutkiewicz (1998) and Stone (2000) provide emission factors for tailpipe exhaust emissions applicable to South African motorised vehicles. These emission factors were calculated for diesel (light and heavy vehicles) and petrol (passenger and light commercial vehicles for non-catalytic and catalytic) motor vehicles for coastal and interior, elevated conditions in South Africa. However, neither Wong and Dutkiewicz (1998) nor Stone (2000) provide specific emission factors for buses and passenger diesel vehicles, and furthermore, the emission factors do not include nitrous oxide (N<sub>2</sub>O), and PM for petrol vehicles. It is also noted that these emission factors are not expressed as a function of vehicle speed.

It is generally accepted that the motor vehicle situation in South Africa resembles that of Europe rather than the United States (Wong, 1999), allowing for the use of European transport emission models. It has been shown that the emission factors developed for South Africa by Wong and Dutkiewicz (1998) and Stone (2000) are in general agreement with the emission factors that are used in the EEA Computer Program to Calculate Emissions from Road Transport (COPERT) model (DoT, 2002). More recently, Forbes and Labuschagne (2009) have found that under dense traffic conditions around Johannesburg, South Africa, COPERT values for Euro 2 emissions were only slightly higher than measured data from motor vehicles and that Euro 3 COPERT emission factors were about three times lower. The South African motor vehicle fleet is generally considered to be old, as more than 50% of motorised vehicles are over ten years old

(Stead and Molden, 2009), hence a large proportion of current motorised vehicles were purchased prior to legislative controls on emissions and therefore for the time period of this study are not expected to meet Euro 2 or Euro 3 standards. Due to the limitations of existing South African emission factors and the average age of motor vehicles in the country, the COPERT emission factors and the COPERT model were deemed suitable for the purposes of this investigation.

Detailed descriptions of the COPERT model are provided by Gkatzoflias *et al.* (2007). The COPERT IV model allows for a variety of estimates of motor vehicle emissions that include CO<sub>2</sub>, N<sub>2</sub>O, CO, methane (CH<sub>4</sub>), sulphur dioxide (SO<sub>2</sub>) and NO<sub>x</sub>. Model inputs include vehicle counts, vehicle fuel type, fuel consumption, vehicle fleet composition or technology, vehicle mileage, and typical average speed. Details of the data inputs and assumptions made to compile activity data for the model are described below.

### **3.1.2 Activity data inputs**

#### ***Vehicle speed***

Information on speed was taken from various sources including case studies of major roads and from permanent traffic monitoring stations operated by the National Road Agency. This was supplemented by published data from Bester and Geldenhuys (2007) and Stone and Bennet (2001), who characterise average speed by vehicle type on major roads in South Africa, including those in Durban.

#### ***Fuel specifications, temperature and Reid vapour pressure***

Fuel specifications used were obtained from the South African National Standards for unleaded petrol SANS 1958 (SANS, 2006a) and for diesel fuel from SANS 342 (SANS, 2006b). Temperature data were obtained from the South African Weather Services and Reid vapour pressure data were obtained from the strategy to control the vehicle exhaust emissions (SA, 2003).

### *Vehicle classification according to the COPERT categories*

The National Association of Automobile Manufacturers of South Africa (NAAMSA) and Response Group Trendline supplied information about the vehicle parc for Durban. The data included the population of motor vehicles, classified by their maximum total weight, and fuel type, and applied to passenger vehicles, light duty vehicles, heavy duty vehicles and buses. There were no data on motorcycles, however, since motor cycles comprise less than 2% of the current motor vehicle parc, (Coetzee, 2008) their exclusion is justified. The vehicle parc data further did not include the numbers of vehicles of automobile manufacturers that are not members of NAAMSA, which are estimated to contribute 0.6% of the motor vehicle fleet in Durban.

The COPERT model requires that vehicles be classified according to engine capacity, weight and emission control technology, i.e. within the designated COPERT vehicle categories. It is known that for the period 1990 to 2002, only 7.3% of the total vehicle population in South Africa was equipped with catalytic converters, and that for the period 2004 to 2006, the corresponding figure for all new motor vehicles was 50% (DEA, 2008). This information together with the introduction dates for emission regulations for new motor vehicles, trends in vehicle sales data (NAAMSA and Response Group Trendline) and literature sources (Lisowski *et al.*, 1996; Coetzee, 2008) were used to estimate the average age of vehicles in the parc, and further classify Durban's motor vehicle fleet into the different vehicle emission control categories specified in the COPERT model as shown in Table 2 below.

**Table 2: Percentage distribution of vehicles estimated according to European emission standards estimated for 2008**

<b>European Category</b>	<b>Petrol passenger vehicles</b>	<b>Diesel passenger vehicles</b>	<b>Light-duty vehicles</b>	<b>Buses</b>	<b>Heavy-duty vehicles</b>
ECE15-00/01	85				
Open Loop	7				
Conventional		40	84	82	83
Euro 1	4	44	6	13	13.3
Euro 2	4	16	10	5	3.7

### *Fuel balance and mileage*

Fuel sales data for 2008 in the seven licensing districts within the municipality were obtained from the Department of Minerals and Energy. As the municipality is central to many road-freight corridors and is a tourist destination it can be assumed that significant amounts of fuel purchased elsewhere are used in the municipality and that fuel purchased within the municipality is being transported beyond its borders. An assumption was therefore made that fuel exports and imports in the municipality balance.

The fuel sales data have two purposes within this study. Firstly, they are used within the model to estimate emissions of CO<sub>2</sub>, SO<sub>2</sub> and lead which are directly related to the amount of fuel that is used. The model assumes that all of the carbon and sulphur present in the fuel is fully oxidised into CO<sub>2</sub> and SO<sub>2</sub> respectively. Secondly, when using an assumption of fuel balance, actual fuel sales can be used within the COPERT algorithm to estimate annual mileages. Annual fuel consumption, fuel consumption factors and the age of motor vehicles are required to do so. As there were no official statistical data available for mileages in Durban, estimates of annual mileages were derived using this algorithm and were further disaggregated based on vehicle mileage degradation profiles developed for South African motor vehicles. The model further requires the percentage driving share of motor vehicles on different road types (urban, rural and freeway). This fraction was estimated using the total length of the local road network, the total length of freeway and the total length of the freeway and main roads.

Information regarding annual mileages of motor vehicles in South Africa and in the province of KwaZulu-Natal were sourced from the literature and questionnaires requesting mileage data were sent to industries and logistics companies within the municipality. This information was used for comparison with estimated mileages from this study. It was found that estimates of passenger motor vehicles and light duty motor vehicles were within +5 to 10 %, whilst heavy-duty vehicles estimates in this study ranged between -15 to +30% of annual mileages reported.



### 3.2 Road transport emissions inventory for 2008

The data described in section.3.1.2 were used as inputs into the COPERT IV model to develop a baseline inventory for 2008 of atmospheric emissions focusing on the major air pollutants (NO<sub>x</sub>, CO, PM) and GHGs (CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O). The emissions calculated are shown in Table 3. These results provide an indication of the major contributors within the motor vehicle fleet to air pollution and GHGs. Of particular interest is the role of passenger motor vehicles and heavy-duty vehicles. Passenger vehicles contribute significantly to CO emissions and CO<sub>2</sub> and NO<sub>x</sub>, whereas the heavy trucks are of a concern for CO<sub>2</sub>, NO<sub>x</sub> and PM.

**Table 3: Baseline emissions calculated (tonnes per annum)**

Vehicle Type	Greenhouse Gases			Air Quality Pollutants			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	PM <sub>10</sub>	NO <sub>x</sub>	CO	SO <sub>2</sub>
<b>Passenger cars</b>	2 140 251	1 363	115	260	25 940	180 563	670
<b>Light vehicles</b>	1 252 630	542	52	610	12 884	31 452	417
<b>Heavy-duty vehicles</b>	2 467 597	140	68	1 518	31 163	9 990	779
<b>Buses</b>	174 457	21	3	108	2 478	617	55
<b>Total</b>	6 034 935	2 066	238	2 496	72 465	222 662	1921

#### 3.2.1 Comparison of 2008 emission inventory compiled for this study with other emission inventories

The determination of emissions is based on a number of assumptions which may induce a bias in the estimation of air quality and climate change pollutants. These include a conservative approach to classifying all vehicles purchased prior to 1990 as being ECE 15.01 and the estimation of annual mileage based on fuel consumption data which was assumed to be constrained by fuel consumption in the municipality.

In order to determine if the baseline inventory that was developed is suitable for further investigations, it was compared with other road transport emissions inventories undertaken for the Durban as shown in Table 4.

In terms of air pollution there are similarities between the different inventories. The relatively higher emission estimates for PM<sub>10</sub> and NO<sub>x</sub> found in this study can be attributed to an increase in vehicle activity and changes to the vehicle fleet over time. It is estimated that over the period of 2002-2008 the number of motor vehicles in the municipality increased by about 10%, with the number of new diesel vehicles being almost three times that of new petrol vehicles.

**Table 4: Comparison of 2008 emission inventory compiled for this study with other emission inventories (tonnes per annum)**

<b>Pollutant</b>	<b>GHG Inventory for 2002 (EM, 2003)</b>	<b>Scorgie <i>et al.</i> (2004)</b>	<b>KwaZulu-Natal Emission Inventory (KZN-DAEA, 2007)</b>	<b>State of Energy Report (EM, 2005)</b>	<b>GHG Inventory for 2005/2006 (EM, 2007b)</b>	<b>This Study</b>
<b>PM<sub>10</sub></b>		2 286				2 496
<b>NO<sub>x</sub></b>		62 456	61 163			72 465
<b>CO</b>		161 791	351 521			222 662
<b>CH<sub>4</sub></b>		915				2066
<b>CO<sub>2</sub></b>	3 308 435	4 657 456		4 489 988	5 5527 709	6 034 935
<b>N<sub>2</sub>O</b>		167				238

The CO estimates of the KZN-DAEA (2007) inventory are significantly higher than other studies and can be explained as they used emission factors that were developed in 1995, during the brown haze study in Cape Town, thus sampling older vehicles, whereas Scorgie *et al.* (2004) made use of the emission factors, developed by Wong and Dutkiewicz (1998) and Stone (2000) which as described earlier are similar to the COPERT emission factors used in this study.

For climate change pollutants, similar emission factors were used in all studies. Fuel sales in the years of these studies explain the differences in estimated CO<sub>2</sub> emissions, as fuel sales in the municipality for 2008 increased by about 30 % compared to 2003.

The inventory developed in this study appears to be representative of the air pollution and GHG emissions in Durban and is therefore regarded as suitable to use as a basis for understanding the opportunities for co-benefits that may exist based on the present characteristics of the motor fleet and fuel consumption.

#### **4. Options for reducing road transport emissions**

Numerous technological and policy-based strategies have been shown to be effective in simultaneously reducing air pollution and GHG emissions from this sector. Interventions that decrease the emissions per kilometre travelled by effecting changes to vehicle technologies, fuel types and distances travelled have been shown to be successful. Opportunities to reduce emissions from this sector in Durban are explored in this section.

##### **4.1 Passenger motor vehicle fleet**

###### **4.1.1 Petrol motor vehicles**

Currently, petrol-driven motor vehicles dominate the passenger fleet in Durban, with diesel vehicles comprising only ~5% of the total. The split between the number of petrol and diesel vehicles plays a key role in determining the CO<sub>2</sub> emissions intensity and air pollution contribution of the passenger motor fleet, due to differences in fuel combustion characteristics and vehicle technologies.

The petroleum used by motor vehicles is made up of a mixture of aromatic hydrocarbons and paraffins, which combust at very high temperatures in the air. The incomplete combustion of the petroleum in the engine of the vehicle results in exhaust emissions of CO, volatile organic compounds (VOCs) (ozone precursor gases), and PM. The installation of catalytic converters on petrol-driven vehicles allows for the combustion of the pollutants at lower temperatures (Heck and Farrauto, 2001) and is effective in reducing the amount of photochemically reactive hydrocarbons by 95%, with the ability to reduce the emissions of CO to below 1%.

Due to the age of the petrol-driven passenger vehicles in the municipality, the majority of petrol-driven vehicles are not fitted with pollution control technologies and are therefore a source of

high air pollutant emissions as shown in Table 3 above. Renewal of the oldest passenger motor vehicles in the parc with newer motor vehicles of advanced vehicle technologies is one option to reduce air pollution.

The inputs into the COPERT model as described in section 3.1.2 were changed to reflect a 20% replacement of petrol-driven passenger vehicles that have Pre-Euro standards by petrol-driven vehicles that are Euro 2 and Euro 3 compliant (20% was chosen as a convenient figure). Based on motor vehicle degradation profiles for South Africa, we find that older passenger vehicles are generally driven less, thus the fleet renewal is expected to result in an increase in vehicle kilometres travelled (VKT) and in fuel consumption. CO<sub>2</sub> emissions therefore increase, whereas emissions of the ozone precursor gases (NO<sub>x</sub>, CO) and PM which have impacts for human health and for climate change are reduced due to improved vehicle pollution technologies (Table 5).

#### **4.1.2 Diesel motor vehicles**

Diesel-fuelled vehicles generally have better fuel economy than petrol vehicles, and have been shown to emit less CO<sub>2</sub> per kilometre (Mazzi and Dowlatabadi, 2007). The effect of replacing 20% of the oldest petrol-driven motor vehicles with new diesel motor vehicles is shown in Table 5. Decreases in ozone precursor gases and CO<sub>2</sub> are noted, however, PM emissions increase as is expected due to the way that diesel fuel is combusted in diesel vehicles, which produces more carbonaceous emissions.

PM emissions from diesel vehicles can be reduced by diesel particulate filters (DPFs), which are made up of filter materials that are placed in the exhaust to collect any PM which is then combusted by oxidizing agents in the exhaust gas. DPFs can have efficiencies of up to and greater than 90% (Coffey, 2004) and when retrofitted on a diesel engine can reduce the effective carbon footprint by at least 20% (Johnson, 2008). These devices have been widely applied to large vehicles such as buses and construction equipment, whereas their use in passenger vehicles is still limited (Ntziachristos *et al.*, 2005). Measures aimed at increasing the share of diesel motor vehicles within the passenger fleet could therefore have conflicting environmental implications.

### **4.1.3 Fuel switching**

As fossil fuels contribute toward significant emissions there is a shift in research and policy to promote more renewable forms of energy such as biodiesel. Biodiesel is manufactured from vegetable oils or animal fats that have undergone a process of transesterification that is used to improve the fuel properties, thus making it a viable alternative to diesel (Atadashi *et al.*, 2010). It is generally acknowledged that when the entire life-cycle of the biodiesel is considered, it is likely to result in lower CO<sub>2</sub> emissions (Gaffney and Marley, 2008). The introduction of biodiesel in South Africa has been slow and due to the lower number of diesel vehicles in the passenger fleet, switching to biodiesel (Table 5) may not make a significant contribution to emission reductions.

### **4.1.4 Reducing vehicle kilometres travelled**

Changes to vehicle technologies alone cannot bring about the emission reductions that are required in the short-to medium-term, highlighting the need for behavioural change, specifically, targeting the VKT by passenger motor vehicles. Interventions that keep the number and type of motor vehicles constant but reduce the VKT and thus reduce fuel consumption, allow for the simultaneous reduction of air pollutants and GHGs (Table 5). Specifically, it results in emission reductions of 15-21% across the pollutants. As CO<sub>2</sub> emissions are more closely related to fuel consumption, higher reductions occur compared to NO<sub>x</sub> and CO which also rely on changes to vehicle technologies as shown earlier.

Currently, walking, cycling and public transport are not popular modes of travel due to poor road infrastructure and concerns over road safety (Bester and Geldenhys, 2007). Improvements to the public transport fleet and policy aimed at encouraging a shift away from motorised private transport are therefore needed. A range of measures based on the principles of road transport management need to be considered, and implemented according to their feasibility and a cost-benefit analysis.

**Table 5: Passenger motor vehicle emissions (tonnes per annum)**

Scenario	Greenhouse Gases			Air Quality Pollutants			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub>	CO	PM <sub>10</sub>	SO <sub>2</sub>
Baseline	2 140 251	1363	115	25 940	180 563	260	670
Fleet renewal with 20% new petrol vehicles	2 160 482	1128	105	21 414	148 145	256	697
Fleet renewal with 20% new diesel vehicles	2 129 071	1134	104	22 139	144 561	391	692
20% use of biodiesel	2 118 288	1345	115	25 681	178 725	260	707
20% reduction in VKT	1 755 571	1076	92	20 545	142 980	208	571

#### 4.2 Heavy-duty vehicles

Transport and logistics related activities contributed for 16% of the Gross Domestic Product (GDP) in 2007 (EM, 2009). The Durban to Gauteng corridor, via Johannesburg represents the busiest road freight transport route, representing over 66 % of road freight transport to or from the municipality. The retail and light industrial sectors located within the municipality account for over 70% of the freight trips that are made (ETA, 2005), with an estimated 27.5 million tons of road freight moved along the Durban to Gauteng corridor annually (KZN Transport, 2009).

The contribution of road freight transport to emissions can be attributed to the fact that South Africa permits some of the largest vehicle combinations in the world for general freight haulage, with vehicle carrying capacities and dimensions that make road transport more competitive than rail (Lane, 2009). Road freight transport thus has numerous advantages over rail transport, which include accessibility, competitive pricing and the ability to cover as much as 18 000 km per month compared to average locomotive which travels 7 500 km per month (Lane, 2009). Furthermore, the rail route between Durban and Johannesburg is about 20% longer than the road

corridor (Morton *et al.*, 2006). The tonnage carried by road freight is almost twice that of rail, irrespective of the direction of the freight, with the rail link between these cities being utilised at less than 35% of its capacity (ETA, 2005).

The Durban port handles more than 60% of all containers arriving at ports in the country (Smit, 2009). The movement of freight from the harbour through to the city represents the most heavily trafficked freight routes. In recent years, engineering techniques such as the widening of roads and the development of truck staging areas have been used to solve problems of congestion on these routes. In the long-term it has been suggested that greater use of the rail system, operated on renewable energy, could be a viable option to reduce the numerous negative impacts associated with road freight transport (SA-ASPO, 2008).

However, in the short- to medium-term, effort needs to be expended in reducing inefficiencies in the current road freight transport system through a movement toward road freight traffic management (Hull *et al.*, 2008). Specifically, measures targeted at efficiency improvements, operational improvements, behavioural change programmes and speed control need to be explored. As improved logistics and efficient vehicle loading are suggested to be the most viable solutions to tackle emissions from this sector (Chapman, 2007), the use of freight internet based systems to match up spare vehicle capacity and freight needs and reducing the occurrence of empty running costs by finding return loads has to be a priority.

Interventions that reduce the VKT by heavy-duty trucks and fuel consumption can contribute to significant reductions in air pollution and GHG emissions (Table 6). Emissions of pollutants are reduced by 20-24 %. The higher reduction in CO<sub>2</sub> in this scenario compared to that of reducing VKT in the passenger vehicle fleet can be attributed to heavy-vehicles being operated primarily on diesel compared to the passenger fleet which is dominated by petrol-driven vehicles.

**Table 6: Heavy-vehicle emissions (tonnes per annum)**

	Greenhouse Gases			Air Quality Pollutants			
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O	NO <sub>x</sub>	CO	PM <sub>10</sub>	SO <sub>2</sub>
Heavy-duty vehicles	2 467 597	140	68	31 163	9 990	1 518	779
20 % reduction in annual VKT in normal fleet	1 881 797	112	54	24 930	7 992	1 214	590

## **5. Discussion and concluding remarks**

This paper provides an indication to policy-makers of the opportunities for co-control of emissions within the road transportation sector and should be considered when designing and implementing new road transport and air quality policies. It should however be noted that there are some uncertainties associated with these emissions estimates and that the purpose of this study is not to provide definitive reductions based on the recommended interventions, but rather to provide an indication of the reductions that are possible and how the various components that contribute to the emissions are related and can be manipulated to decrease emissions. It has to be acknowledged that the emission reductions estimated in this study may differ under real-world driving conditions. Furthermore, emission reductions may not necessarily equate to similar reductions in ambient concentrations of pollutants.

Emissions from road transport were shown to be most sensitive to distances travelled and vehicle technologies. Interventions that promote improved efficiency in road freight transport and reduced use of private passenger motor vehicles are likely to yield the most significant emission reductions. Furthermore, as the South African government plans to implement cleaner fuels regulations, the benefits of this policy can only be realised if measures are put in place to reduce the number of old, polluting motor vehicles. Therefore the motor vehicle parc, especially the passenger motor vehicle fleet needs to be rejuvenated in order to realise the effects of cleaner fuels. A combination of fleet renewal and reducing VKT needs to be explored.

Using a co-benefits approach when developing policy to reduce emissions from this sector, will allow for more effective emission reduction strategies to be developed. By taking cognisance of GHG implications, the implementation of air quality interventions that may make future GHG emission targets more difficult and costly to attain is avoided.

If the city of Durban is to aggressively tackle GHG emissions from road transport, the uncertainty around data mentioned in this study needs to be rectified. Specifically, the development of emission factors, availability of mileage data and improved characterisation of the motor vehicle fleet is needed. Even with a complete data base of mileage of motor vehicles registered in the municipality, there is considerable uncertainty with regard to inter-municipal travel that needs to be investigated. Motor vehicles used in the municipality that are registered or fuelled out of the municipality and vice versa need to be investigated to allow for the



representation of the activity of inter-municipal travelling vehicles, especially that of heavy-duty vehicles.

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