REPORT ON GLOBAL FUEL ECONOMY INITIATIVE STUDY IN KENYA (GFEI)

UNIVERSITY OF NAIROBI ENTERPRISES AND SERVICES LTD (UNES)

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ARI	Acute Respiratory Illnesses
ASEAN	Association of Southeast Asian Nations
BC	Black Carbons
CAFÉ	Corporate Average Fuel Economy
CBA	Cost-Benefit Analysis
CIF	Cost, Insurance and Freight
CO_2	Carbon Dioxide
CO_2/km	Carbon Dioxide per Kilometer
DALYs	Disability Adjusted Life Years
DW	Disability weight
EA	Environmental Audit
EAC	East African Community
EIA	Environmental Impact Assessment
EMCA	Environmental Management and Coordination Act
ERC	Energy Regulatory Commission
FEPit	Fuel Economy Policies Impact tool
gCO_2/km	Grams of carbon dioxide emitted per kilometer travelled
GDP	Gross Domestic Product
GFEI	Global Fuel Economy Initiative
GHGs	Greenhouse Gases
GMEA	General Motors East Africa
IEA	International Energy Agency
IRR	Internal Rate of Return

ISO	International Organization of Standards
ITF	International Transport Forum
JCO8	Fuel consumption measurement method applied to a vehicle subject to approval in Japan
KEBS	Kenya Bureau of Standards
KENGEN	Kenya Electricity Generating Company
KMIA	Kenya Motor Industry Association
KNH	Kenyatta National Hospital
KRA	Kenya Revenue Authority
L/100km	Litres per 100 Kilometers
LDV	Light Duty Vehicles.
MOE	Ministry of Energy
MoT Test	Ministry of Transport test, United Kingdom
MPV	Multi-Purpose Vehicle
MVIU	Motor Vehicle Inspection Unit
NAAMSA	National Association of Automobile Manufacturers of South Africa
NCD	Non-Communicable Diseases
NEDC	New European Driving Cycle
NEMA	National Environment Management Authority
NOx	Nitrogen Oxides
NPV	Net Present Value
NTSA	National Transport and Safety Authority
OECD	Organization for Economic Co-operation and Development
PCFV	Partnership for Clean Fuels and Vehicles
PIEA	Petroleum Institute of East Africa

PM	Particulate Matter
SUVs	Sports Utility Vehicles
ToR,	Terms of Reference
UK	United Kingdom
UNEP	United Nations Environment Program
UNES	University of Nairobi Enterprises and Services Limited
UNFCCC	United Nations Framework Convention on Climate Change
USA	United States of America
USD	United States Dollar
VKM	Vehicle Kilometers Covered
WHO	World Health Organization
YLD	Years Lost due to Disability
YLL	Years of Life Lost

EXECUTIVE SUMMARY

In March 2009, the United Nations Environment Program (UNEP) in collaboration with the International Energy Agency (IEA), the International Transport Forum (ITF) and the Federation Internationale de Automobile (FIA) foundation launched the Global Fuel Economy Initiative (GFEI). The aim of the project was to reduce localized air pollution, greenhouse gas emissions and global national fuel bills through the promotion of cleaner fuel efficient vehicles.

The pilot project was proposed to cover Chile, Ethiopia, Indonesia and Kenya. The task entailed updating the vehicle inventories of the respective countries, with the aim of establishing the country's average fuel economy (baseline setting) and carrying out a cost benefit analysis of the different policy options that promote fuel efficient vehicles. Such analysis should inform the respective governments on the right combination of technologies and policy instruments needed to meet the national gas emission standards, energy security and fuel efficient goals.

In Kenya, UNEP collaborated with the Energy Regulatory Commission (ERC) to undertake the pilot project. The ERC subsequently contracted the University of Nairobi Enterprises and Services Limited (UNES Ltd), to carry out the project on its behalf. The UNES consultancy project was mandated to establishing the vehicle inventory for the country between the years 2010 and 2012. Consequently, the study used the vehicle inventory data to conduct a Cost Benefit Analysis (CBA) and health analysis for the prevailing fuel economy and emission standards. The consultant was also to carry out a survey of the existing regulations governing the transport sector in Kenya.

The study covered the following aspects:

(i) Vehicle Inventory

The records of registration of vehicles in Kenya for the years 2010, 2011 and 2012, was obtained from the Registrar of Motor Vehicles (RMV) which is a department of

Kenya Revenue Authority (KRA). The focus of GFEI study is the category of vehicles with a gross weight of less than 3500 kg. These categories of vehicles are referred to as Light Duty Vehicles (LDVs). The data availed consisted of 300,094 LDVs with eleven descriptive variables for each make of vehicle. The variables included vehicle model, year of manufacture, fuel type, tare weight, usage, among others.

The primary data necessary to develop the fuel economy database is the fuel consumption level in L/100 km and CO_2 emission level in g/km. Average vehicle fuel consumptions and CO_2 emission levels were obtained from published data sets found in the websites of vehicle manufacturers', national government statistics, UK Vehicle Certification Agency (VCA), US Environmental Protection Agency (EPA), and the UNEP databank, among other sources.

The fuel consumption values were based on the New European Drive Cycle (NEDC) test cycle and where other test cycles were used, a conversion factor from global standards review was used to obtain the NEDC equivalent.

The following trends were observed in the LDVs registered during 2010-2012 period.

1. The annual registration had increased from 33,917 in 2003 to 110,474 in 2012.
2. Projections of the cumulative total vehicle registrations on the basis of the trend during the 2003 to 2012 period predict a vehicle population of 5 million in 2030 and 8.7 million in 2050.
3. The predominant engine displacement of the vehicles registered in the country is that of 1500 cc to 2000 cc which form 35% of the registered vehicles, followed by capacities above 2500 cc at 19% and those with engine capacity below 1300cc constitute only 7%.
4. During the period under study 84% of the vehicles (LDVs) were manufactured in Japan and 10% in Germany.
5. Most (67%) of the LDVs registered during the period of study were seven to eight years old.

The average fuel economy was established as 7.5 L/100km and the average CO_2 emission was 181.9g/km for the period 2010-2012.

During the period under study a conspicuous increase in the number of motorcycles was observed. The number of motorcycles registered increased exponentially from 51,855 in 2008 to 140,153 in 2011. The primary concern associated with the high number of motorcycles is increase in social costs of which increase in the number of accidents is most prominent.

An issue of concern was the insignificant percentage of hybrid vehicles in the country. This was considered unusual but was attributed to a low level of public awareness on environmental degradation and fuel efficiency issues.

(ii) Regulations governing the Transport sector

The laws that have been established to regulate the transport sector in the country include:

1. Traffic Act, Chapter 403

   This law mandates the registrar of motor vehicles to keep track of all motor vehicles and trailers registered in Kenya. Section 51 of the law stipulates that all vehicles of more than 4 years from the date of manufacture should be subjected to inspection by the Motor Vehicle Inspection Unit. The act also provides for existence of inspection centers throughout the country.

2. Integrated National Transport Policy, 2009

   Section 14 of the act proposes the use of lead free and low sulphur fuels. The act stipulates the domestication of efficient and less polluting fuels. It also provides strategies of dealing with the Public Service Vehicles as far as proper maintenance, gas and noise pollution are concerned.

3. National Transport and Safety Authority (NTSA) Act, No. 33 of 2012.

   The act provides for the establishment of the NTSA body, whose functions are to spearhead the implementation of policies in the road transport sector, as stipulated in section 4 of the act. The functions of NTSA include registration, inspection and licensing of motor vehicles.

4. Standards Act, Cap 496

   The prominent standards include:

a) KS 1515:2000 – Code of practice for inspection of road Vehicles

   Stipulates that vehicles should not emit visibly colored smoke, the concentration of carbon monoxide (CO) should not exceed 0.5% by volume and hydrocarbons should not exceed 0.12% by volume.

b) KS 2060:2007 – Motor Gasoline Specifications

   Specifies that the maximum lead level should be 0.015g/L and maximum sulphur level should be 0.15%.

c) KS 1309-1:2010 – Diesel Fuels: Specification

   This act specifies the maximum requirement of fuel sulphur content at 500 ppm.

d) KS 03-1099:1992 – Specification for Engine Oils

   Specifies maximum requirement of sulphur content as 0.05%.

The limitations and impact of these and other existing regulations are determined by the process of enforcement and implementation as it is possible to create a great deal of positive impact in the transport sector in a relatively short time.

(iii) Cost Benefit Analysis

It is projected that the global vehicle fleet will rise significantly by the year 2050. This presents an opportunity for policy makers to design tools that will respond to the expected challenges while ensuring overall economic and environmental efficiency. Reduction in the level of CO_2 emission and the average fuel consumed per kilometer is therefore necessary in enabling fuel efficiency to the vehicles within an economy. Based on the 2012 data of the Kenya motor vehicle inventory, the estimated CO_2 emission is 181.7gCO_2/km and fuel consumption is 7.5L/100km. The global target referred to as "50by50" implies achieving a 50 per cent reduction in CO_2 emission level and average fuel consumption by the year 2050.

Various policy interventions were proposed for implementation to attain the targets. The CBA methodology was grounded on a public welfare perspective and based on a discounting rate of ten (10) per cent, fuel efficiency costs and benefits based on pump prices; environmental costs and benefits based on CO_2 emission; and public health costs based on the direct medical costs of treating respiratory illnesses. The average fuel economy and CO_2 emission results were utilized for the purpose of projecting the expected CO_2 emission and the average fuel consumption up to the year 2050. Additionally, the Net Present Value (NPV) and Internal Rate of Return (IRR) were used as the criterion for accepting or rejecting a policy intervention.

The analysis showed that at the current fuel economy level (7.5 L/100km), based on the total vehicle fleet, it costs the economy approximately KShs 400 billion per year in petrol fuel consumption at prevailing pump prices. The estimates for diesel were computed using the same approach, yielding a cost of KShs. 3.6 billion p.a. Expenditure on motorcycle fuel consumption was estimated at KShs. 20 billion p.a. At the same time, estimation of vehicle CO_2 emissions based on an average of 181.7gCO_2/km in the year 2012 indicated total emissions of 717 thousand tonnes of CO_2 valued at KShs. 609 Million.

The options listed in Table 1 were subjected to Cost Benefit Analysis and it was the adoption of a policy mix that yielded highest savings. While vehicle options as stand-alone had higher impacts than stand-alone tax options. Other fuel efficiency options that were considered are illustrated in Table 1.

Table 1: Options on fuel and CO_2 emission controls

Transport Sector Management Options	Scenarios
Option 1: Status Quo	▪ Predominantly based on vehicle technology changes ▪ No enhanced enforcement of regulations ▪ No inspection routines for vehicles ▪ Current state of infrastructure
Option 2: All policies implemented	▪ Full regular inspection and enforced compliance to existing standards ▪ Improved infrastructure, high vehicle and tax options ▪ Increased population of hybrid vehicles
Option 3: Vehicle Options	▪ Labeling of CO_2 emission by vehicles ▪ Enhanced restriction on age of imports ▪ Cost of vehicles based on CO_2 emission
Option 4: Fuel Tax Options	▪ Tax and levies on fuel ▪ Taxation incentives on acquisition of fuel efficient vehicle

The health implications of transport related burden was also quantified. Prevalence of respiratory diseases related to air pollutants was greater than 90% in 2010, 2011 and 2012. The high (more than 90%) prevalence among persons of over 5 years concurs with previous studies in Kenya. Disability Adjusted Life Years (DALYs) was computed as 20,639,387 years, which has large implications on productivity as many active years are lost.

(iv) Recommendations

The following recommendations were made at the conclusion of the study:

a) Vehicle Inspection

The Motor Vehicle Inspection Unit to develop capacity to:

- Conduct regular inspection inclusive of monitoring of emissions for all vehicles.
- Increase capacity of the unit or license credible garages to provide the inspection services to all vehicles and motorcycles.

b) Taxes

The state to establish mechanisms to:

- Develop fuel tax options / tax rebate systems in relation to CO_2 emissions and fuel efficiency levels.
- Reduce per capita annual kilometers travelled through travel demand management strategies.

c) Infrastructure and transport planning

The state to establish a framework for provision of mass transit (Bus/Train) to enhance a shift from private car dominance.

d) Health surveillance

The state to establish a framework to:

- Continuously conduct surveillance of total suspended particulate (TSP) matter and elemental concentrations.
- Conduct periodic estimation of economic burden of vehicle emission related illnesses to plan and implement control and prevention policies and programs.

e) Vehicle and fuel Standards

The state to establish a framework to:

- Phase out motorcycles with two stroke engines on account of high pollution and fuel consumption.
- Implement all relevant existing standards

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1. INTRODUCTION

1.1 Background

Road transport is a key element in the mobility of goods and people. It is also a significant energy end-use sector world-wide and thus a major contributor to the increasing Global Greenhouse Gas (GHG) emissions as well as other air pollutants. The global vehicle fleet is set to increase three to four fold in the coming decades, with 90% of the growth taking place in developing and transitional economies. The health, environment and climate impacts of this growth will be monumental and there is urgent need to ensure that most fuel efficient technology and enabling policies are adopted across the globe.

Fuel consumption by transport is expected to increase rapidly due to urbanization and economic growth resulting in greater demand for mobility. Countries that rely on fuel imports will experience increasing pressure on their national budgets. Thus, improving efficiency will contribute to lowering dependency on expensive imports and help reduce high fuel expenditures and subsidies. Furthermore, it could free up finances for basic service provision and investment towards the millennium development goals. Research shows that opportunities exist to improve the fuel economy of new vehicles through use of currently available off shelf technologies.

The focus on GHG emissions and especially CO_2 is based on the perceived present and future effects.

National Geographic (2007) explains this as follows:

a) The earth is hospitable because its atmosphere works like a green house, retaining enough sun's heat to allow plants and animals to exist. This natural climate control system depends on the trace presence of certain atmospheric gases to trap the sun's radiations.
b) Gases, principally carbon dioxide, water vapor and methane trap the heat and keep it in the lower atmosphere. Without this natural process the average temperature of the earth could be -18^{0}C and not the present 14.5 ^{0}C.

c) However the human activities of burning of fossils fuels have increased the atmospheric CO_2 to levels unprecedented in human history whereby 23% is attributed to emissions from the transport sector.
d) CO_2 comes from thermal power plants that generate electricity, transport vehicles fueled by petrol and diesel and industrial combustion processes.

Global Fuel Economy Initiative (GFEI) has identified that improving the fuel efficiency of road vehicles is one of the most cost effective and feasible measures for stabilizing CO_2 emissions from road transport.

1.2 Objectives of the Study

The objectives of the study were to:

a) Develop an inventory of vehicles in the country during the period; 2010, 2011 and 2012 and assess the trend in average fuel economy and CO_2 emissions.
b) Review existing national regulations and incentives to promote cleaner and fuel efficient vehicles.
c) Establish the amount of CO2 emission, costs of emission and related illnesses
d) Conduct Cost Benefit Analysis (CBA) of the various policy interventions.
e) Conduct a national workshop

1.3 Scope of Work

The scope of the work, in line with the Terms of Reference (ToR) comprised of the following components:

a) Carry out a detailed inventory of the current vehicle population and emerging trends in Kenya during; 2010, 2011 and 2012 period.
b) Access and analyze government regulations and incentives to promote cleaner and fuel efficient vehicles and recommend appropriate interventions.
c) Conduct socio-economic implications analysis (CBA) of the various interventions to promote cleaner fuels and vehicles. The aim was to identify

and value the economic, financial and social benefits and costs of identified policy interventions.

d) Analysis of health implications arising from the transport sector, including aspects such as:
   (i) Data collection on morbidity rates attributed to air pollution/ vehicle emissions (respiratory illnesses, cancer etc.)
   (ii) Develop criteria and assumptions for differentiating illnesses attributed to vehicle emissions and other sources of air pollution
   (iii) Show population of people who suffer emission related illnesses (2010-2012)
   (iv) Show mortality rates and number of people who die due to emission related factors
   (v) Estimate the total related costs in USD of emission related illnesses and deaths for the study period (including treatment costs, insurance, loss of productivity and man hours, among others); National cost of treating emission related illness as a percentage/ portion of Kenya GDP / Capital; Loss of a national productivity index due to deaths and lost work days/idle times for the study period and
   (vi) Establish criteria to determine the pollutants of interest to GFEI methodology and compute the benefits/value (in terms of reduction in morbidity and mortality).

The study was intended to support the government in the development of plans and strategies for improved fuel efficiency in the automotive industry and was based on a rigorous process of developing and analyzing vehicle inventory through which information on vehicles registered in the country during the period 2010, 2011 and 2012, was compiled and analyzed.

2 VEHICLE INVENTORY

2.1 Approach

The team adopted a participatory, collaborative and integrated approach as per the Global Fuel Economy Guidelines. The Registrar of Motor Vehicles at Kenya Revenue Authority (KRA) was contacted for primary source of vehicle inventory data. The data was cleaned of typographical and classification errors and missing variables were populated with website information from vehicle manufacturers and government sources. Information on specific new vehicles was obtained from stakeholders in the motor industry namely; Kenya Motor Industry Association, General Motors East Africa and the Ministry of Transport and Infrastructure. The consultation was dynamic and continuous. The final database was populated as to contain all the key parameters that defined the minimum requirements according to the GFEI guidelines.

As expressed in the Terms of Reference, the consultant was guided by the following main documents in designing the study methodology:

a) The Methodological Guide to Developing Vehicle Fuel Economy Databases Prepared for the Transport Unit Division of Technology, Industry and Economics, UNEP by the Climate XL Africa, March 2011.
b) GFEI Tool User Guide, UNEP
c) International Comparison of Light-Duty Vehicle Fuel Economy: An update using 2010 and 2011 new registration data - Working Paper 8.

Thus the key stakeholders consulted included: Energy Regulatory Commission (ERC), the United Nations Environment Programme (UNEP), Kenya Bureau of Standards (KEBS), Kenya National Bureau of Statistics (KNBS), Ministry of Transport and Infrastructure, Kenya Revenue Authority (KRA)–Motor Vehicle Registration Department, General Motors East Africa, National Second Hand Vehicle

Dealers representatives and Kenya Motor Industry Association, the Petroleum Institute of East Africa (PIEA), and Ministry of Environment, Water and Natural Resources.

2.2 Size of Database

The vehicle inventory data was populated from the total registration of light duty vehicles for the period of study. The data as availed by the Registrar of Motor Vehicles consisted of a total of 300,094 LDVs, compiled in approximately 36,000 rows of MS Excel data sheet. This comprised the population of LDVs registered in the country over the period 2010, 2011and 2012. 300,094 were the registered LDVs of which 2972 were classified as new while the balance of 297,122 vehicles were imported after initial use in the countries of origin.

2.3 Vehicle Registration Data

The development of fuel economy and carbon dioxide emissions database was guided by the "Methodological Guide to Developing Vehicle Fuel Economy Databases" prepared for Transport Unit, Division of Technology, Industry and Economics by Climate XL-Africa(UNEP, 2011).

In Kenya, the Registrar of Motor Vehicles - a department of KRA is the official public repository of vehicle registration data. Since 2005, when KRA digitized its registry, it maintains a digital and searchable database of vehicles registered in the country. Through ERC, the Registrar of Motor Vehicles accorded the consultant (UNES) assistance in form of all the relevant information from their digital database. The data availed consisted of 300,094 Light Duty Vehicles (LVD's) of less than 3500 kg gross weight.

Descriptive variables of each model of vehicle included the following:

(i) Number of the vehicles registered
(ii) Condition (new or used)

(iii) Type of body (Saloon, Station Wagon, Pick up,…)

(iv) Make (Toyota, Mitsubishi, …)

(v) Model (Nissan X-trail, Nissan Sunny, …)

(vi) Year of production

(vii) Year of first registration by KRA.

(viii) Fuel type (diesel, petrol, hybrid)

(ix) Engine size (cubic centimeters)

(x) Vehicle use (private / commercial goods)

(xi) Number of passengers

(xii) Tare weight (kilograms)

The focus on vehicles referred to as Light Duty Vehicles (LDVs) whose gross weight is less than 3500 kg was based on the guidelines from GFEI. The key variables for vehicles inventory according to IEA data frame consists of 24 attributes. However the data from the office of the Registrar of Motor Vehicles contained 11 variables which are similar to that recorded in the registration book retained by owner of the vehicle as proof of ownership. The eleven fields captured in the database at the Registrar of Motor Vehicles was however incomplete for purposes of this study in that it did not include names of models and the type of transmission. Though most LDVs possess automatic transmission it was necessary to consider the variable as it has a direct effect on the fuel consumption. Tests on fuel consumption indicate that Multi-Purpose Vehicle (MPV), Sports Utility Vehicles (SUV) and vehicles with automatic transmissions consume up to 10% more fuel. Manual transmission has been shown to improve the fuel consumption by about 1.1 km/litre.

On account of the missing variable, the study assumed the following types of vehicles to be typically having manual transmission and thus established their fuel consumption from the manual transmission specifications:

a) *Matatus* (local 14 passenger seater) and

b) Commercial vehicles

2.4 Data Cleaning

Data availed by the Registrar of Motor Vehicles was cleaned in the following manner:

a) Typographical errors of which the following was typical:

   i) Navara (model of Nissan), was entered variously as: 0D22 Navara, ONavara, ONavara DCL and Navara D22.

   ii) Same model of car was entered variously as OUA WFY 11, UA WFY11, UA-WFY 11, UAWFY11, -UA-WFY11, WFY11-372895 and YA-WFY11

   iii) Other cases were of mismatch in which Toyota Vitz and Rav4 were classified as Matatu/Mini-Bus and Toyota Fielder classified as Saloon.

   iv) A sample page with unclassified entries is shown in Appendix C.

b) The list as availed did not identify models of vehicles by name but by codes. It was found necessary to identify the name of each model of vehicle before carrying out the search of data on fuel economy and CO_2 emissions. Sources of data on internet are predominantly based on name of model.

c) There was need to remove vehicles not classified as LDVs from the database. Vehicles removed included prime movers and the unclassified[1] (i.e., those that lacked clear identity). The final effect of unclassified vehicles on the analysis result was however established as insignificant as it was only 0.72% of all the registered LDVs as illustrated in Table 2-1.

Table 2-1: Percentage of unclassified vehicles on the KRA database

STATUS	NO. OF VEHICLES	VEHICLES (%)
Unclassified	2,372	0.72
Classified	297,722	99.30
Grand Total	300,094	100.00

[1] See appendix for a representation of such rows of unclassified data. The columns named model and descriptions, which are the only details that help identify a vehicle, did not have any entries.

2.5 Populating Missing Fields of Data

The primary data required for developing vehicle fuel economy database is the fuel consumption in L/100km and the CO_2 emission in g/km. Countries that manufacture motor vehicles routinely carry out tests for fuel economy through standard procedures before authorization of the same for sale. The test methods including test cycles vary among countries and regions. The test cycles simulate a range of driving conditions, at highway speeds and at speeds more typical of urban driving.

In most developing economies, vehicles are not tested for fuel economy in domestic laboratories i.e. using domestic test cycles. Governments often rely on published data from manufacturers when calculating vehicle stock fuel economy. In the present study, the data sourced was based primarily on US, European and Japanese test cycles, namely, CAFE, NEDC and JC08 test cycles respectively. Using the methodology developed by International Council on Clean Transportation (ICCT) the values from the various test cycles were converted to corresponding values in the New European Driving Cycle (NEDC). A listing of the main sources of data is included in Annex B.

2.6 Study Assumptions

The following key assumptions were made in the study:

a) The data as received from the Registrar of Motor Vehicles, consisting of 300,094 Light Duty Vehicles (LVD's) of less than 3500 kg gross weight, was the whole population of LDVs registered in Kenya for the years 2010, 2011 to 2012. The population included three wheelers, passenger cars, trucks, buses and mini-buses, vans, pickups and all such vehicles that satisfy the definition of LDVs[2].

[2] A definition of LDVs as understood in this context is provided in the appendix.

b) The data from the office of the Registrar of Motor Vehicle contained 11 attributes, the bare minimum required for a successful GFEI study[3]. These attributes included: *Model, Manufacturer, Body type, Engine capacity, Fuel type, Model year, Registration year, Gross vehicle weight.* The attributes provided were used to source for fuel consumption and CO_2 emissions data. The other 13 attributes are mainly physical and discerning technology attributes of vehicles, which are; *Simplified Body Type, Segment, Axle configuration, Driven wheels, Engine cylinders, Engine kW, kW class, Engine horse power, Engine valves, Number of gears, Transmission type, Turbo and Vehicle Height.* Though these functions complete the description of a vehicle, they are not necessary for establishing the fuel economy and CO_2 emissions.

c) Using the methodology developed by International Council on Clean Transportation (ICCT), the values from the various test cycles were converted to corresponding values in the New European Driving Cycle (NEDC). Coupled with the fact that most fuel economy databases were already in NEDC, it was preferred to base the study on the NEDC test cycle.

d) Where data on vehicle makes and models were not available, particularly for older vehicles, data on the closest model was used on the assumption that there would be marginal variance between one generation model and the subsequent one.

2.7 Population Trends of Registered Vehicles

In the succeeding sections results of the study including trends in vehicle populations, CO_2 emissions and fuel consumption have been summarized in Tables and Figures with appropriate captions and comments.

[3]Methodological Guide to Developing Vehicle Fuel Economy Databases. Climate XL Africa, March 2011.

Table 2-2: New and Used LDV population

YEAR	2010	2011	2012	GRAND TOTAL	%
New	728	1,032	1,212	**2,972**	**1.0**
Used	92,410	95,452	109,260	**297,122**	**99.0**
Total	**93,138**	**96,484**	**110,472**	**300,094**	**100**

Table 2-3: LDV population registered each year

YEAR	2003	2004	2005	2006	2007	2008	2010	2011	2012
No. LDV registered	33,917	42,634	45,652	52,822	85,324	121,831	93,136	96,484	110,474

Source: *KRA datasets*

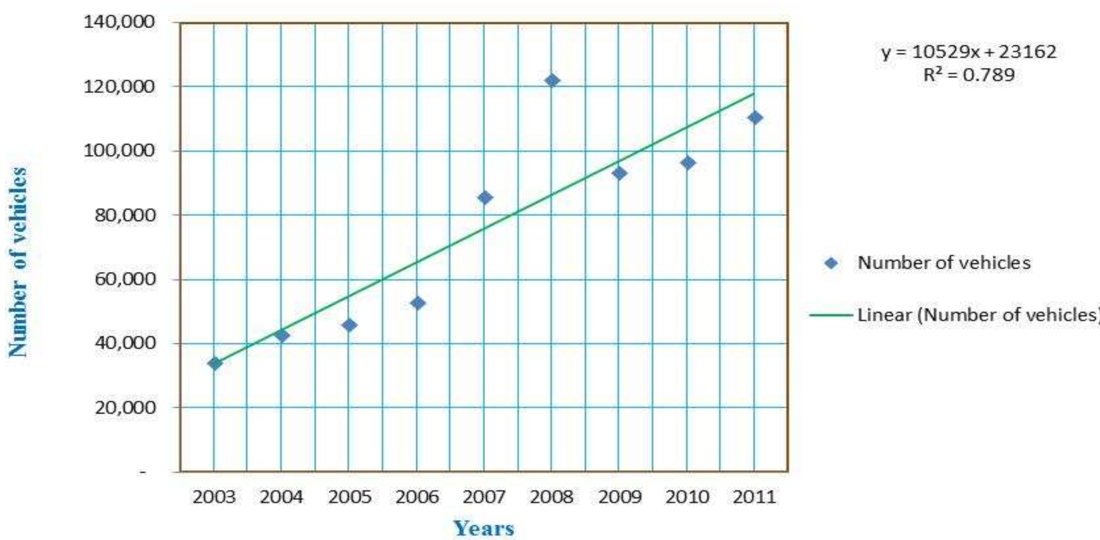

Figure 2-1: LDV population registered each year

Tables 2-2, 2-3 and Figure 2-1 shows the trend in registration of Light Duty Vehicles (LDVs) from 2003 to 2012. On the basis of the best line of fit and continuation of trend, it was projected that a total of 307,445 LDVs would be registered in 2030 and 518,025 LDVs in 2050.

Table 2-4: Cumulative Total Vehicle registrations: Observed and predicted values

YEAR	CUMULATIVE VEHICLE REGISTRATION
2008	1,297,520
2009	1,454,249
2010	1,651,257
2011	1,849,911
2012	2,022,955
2030	5,062,366
2050	8,755,426

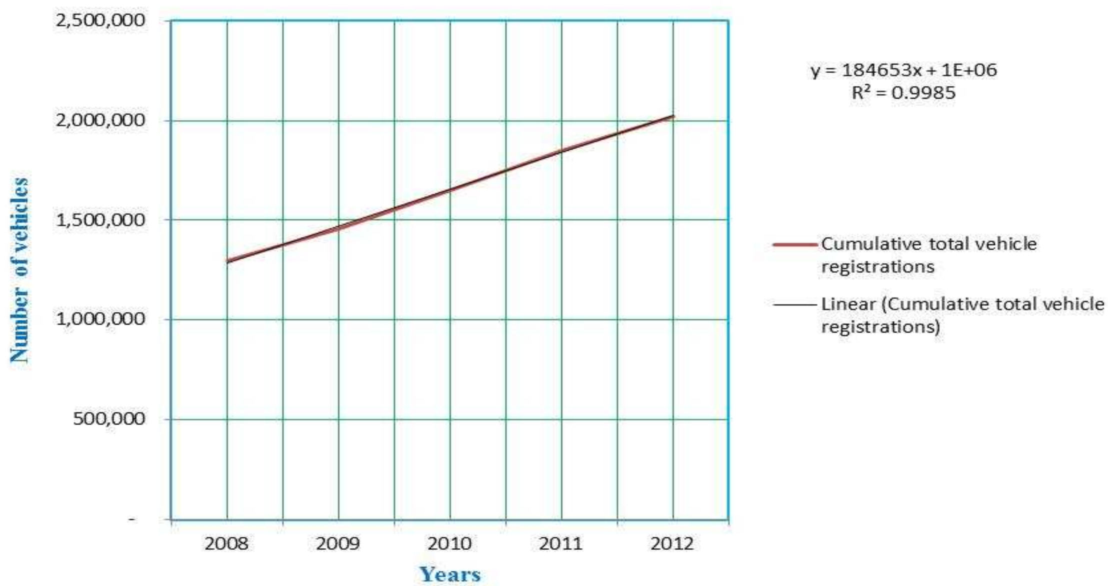

Figure 2-2: Cumulative Total Vehicle Population Registered in Kenya

Table 2-4 and Figure 2.2 show the cumulative total fleet of all types of vehicles registered in Kenya from 2008 when the process of vehicle registration was digitized. The figure shows that approximately 1.5 million vehicles were on Kenyan roads in 2009. Projection for the year 2030, based on the same trend indicates the total fleet would be 5,062,366 vehicles cumulatively. The figure would reach 8 million plus by 2050 on this basic conservative linear extrapolation. Exponential growth estimates would return much larger figures, if the indicators of economic growth were to mimic exponential growth.

Table 2-5: Total number of LDVs registered by engine displacement

Year	Engine displacement (cc)							
	<1000	1001-1,300	1301-1,500	1501-2,000	2001-2500	2500-3500	3500+	Grand Total
2010	900	4,560	31,030	30,870	10,170	13,284	2,322	93,136
2011	878	8,086	23,496	35,034	10,910	12,096	5,984	96,484
2012	888	7,728	33,230	38,756	13,096	11,942	4,834	110,474
Grand Total	**2,666**	**20,374**	**87,756**	**104,660**	**34,176**	**37,322**	**13,140**	**300,094**
%	**0.89**	**6.79**	**29.24**	**34.88**	**11.39**	**12.44**	**4.38**	**100**

Table 2-5 and Figure 2.3 display registration of vehicles by engine displacement. It was observed that the preferred engine displacements (size) were in the ranges of 1301-1500 cc and 1501-2000 cc. Generally, majority of vehicles were of capacities of less than 2000cc and mainly powered by petrol engines. Diesel powered vehicles however become more prominent as the engine displacement increase.

Table 2-6: Percentage of LDVs by fuel type

Fuel Type	2010	2011	2012	Grand Total
Diesel	16.36	13.58	12.04	13.87
Petrol	83.62	86.42	87.96	86.12
Grand Total	**100.00**	**100.00**	**100.00**	**100.00**

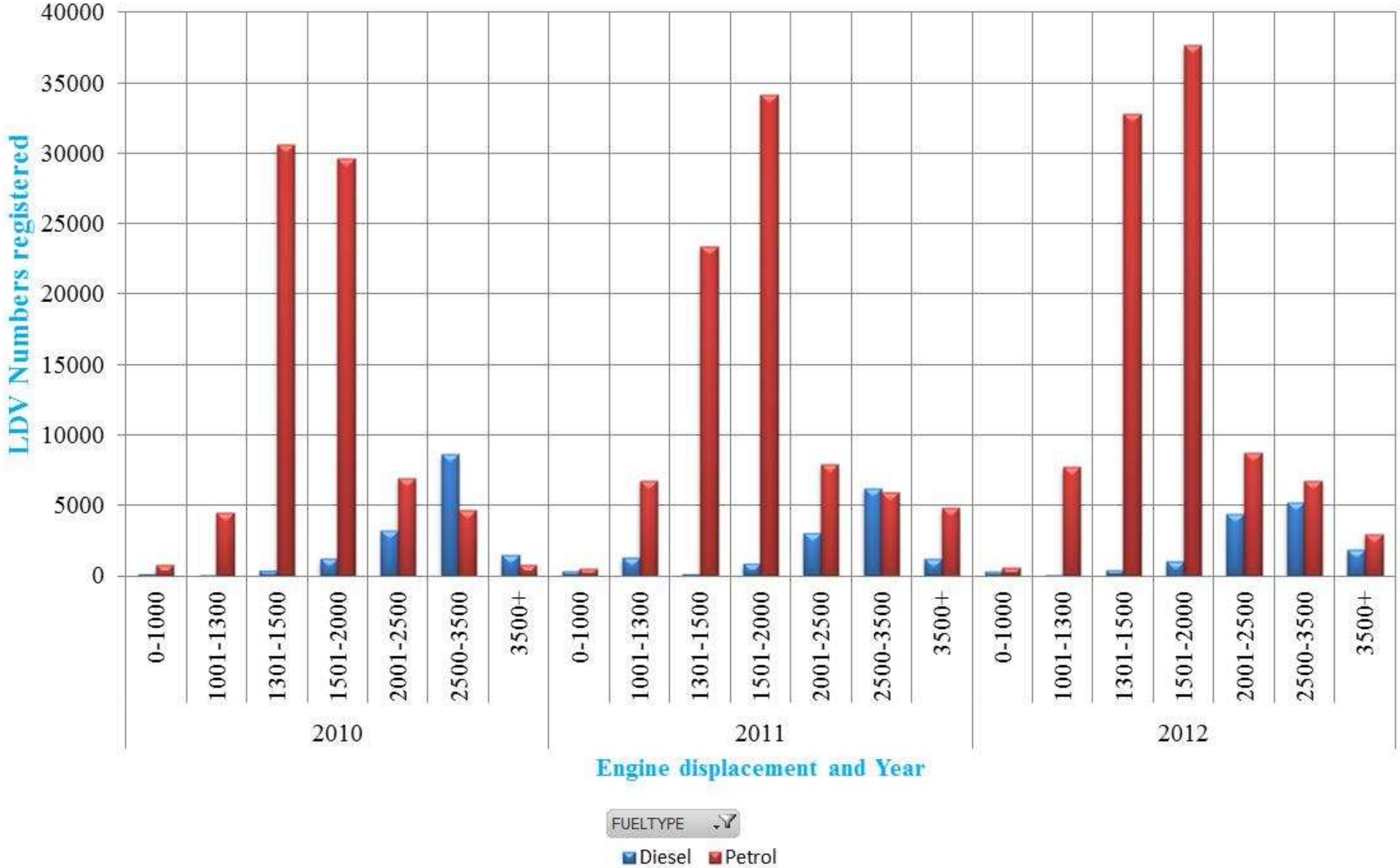

Figure 2-3: Registration of LDVs by engine displacement and fuel types

Table 2-6 summarizes the percentages of vehicle registration by fuel type and indicates that approximately 86% of LDVs registered between 2010 to 2012 were powered by petrol engines compared to diesel powered types which averaged 14% of the registered LDV fleet.

2.8 Fuel Economy and CO_2 Emission Standards

Europe, Japan, and the United States have each developed their own test procedures to determine fuel economy and GHG emissions from new passenger vehicles. In most developing economies however, vehicles are not tested for fuel economy in domestic laboratories using domestic test cycles. Governments often rely on published manufacturer's data when calculating vehicle stock fuel economy.

The primary fields of data for development of vehicle fuel economy databases, namely the fuel consumption in L/100km and CO_2 emission in g/km were primarily sourced from US, European and Japanese government websites. The test cycles (i.e. vehicle running patterns) used in US, Europe and Japan are CAFE, NEDC and JC08 respectively. The methodology developed by International Council on Clean Transport (ICCT) and conversion factors in Table 2-7 was used to convert values from CAFE and JC08 test cycles to corresponding values of the New European Driving Cycle (NEDC).

The preference for NEDC test cycle was based on the following:

(i) The baseline study of 2005 and 2008 was based on NEDC test cycle and continuation for comparative analysis of developing trends was inevitable.

(ii) A similar study on Improving Vehicle Fuel Economy in the ASEAN in 2010 noted that NEDC was preferred by most countries.

Table 2-7: Test Cycle Conversion Multipliers

Test Cycle	NEDC- JC08	CAFÉ-JC08	CAFÉ- NEDC
SIMPLE_AVERAGE	1.15	1.29	1.12

Source: *International Council on Clean Transport (ICCT) 2007 report titled "Passenger Vehicle Greenhouse Gas and Fuel Economy Standards."*

As illustrated in Table 2-8 and Figure 2-4, findings from the study indicate that the average fuel consumption for vehicles in Kenya in 2010 was **7.4 L/100km** with a corresponding CO_2 emission of **178.2g/km,** the fuel consumption figure in 2011 was **7.6L/100km** with a corresponding CO_2 emission of **182.04g/Km,** while in 2012, fuel consumption figure stood at **7.7 L/100km**, with a CO_2 emission of **185.4g/km**. The grand average figure of fuel consumption for the period of study was **7.5 L/100km** with a corresponding CO_2 emission of **181.7g/km**.

Table 2-8: Average CO_2 emission (g/km) and average fuel consumption in L/100km

Year	Average fuel Consumption Metric combined(L/100km)	Average CO_2 emission(g/km)
2010	7.4	178.2
2011	7.6	182.0
2012	7.7	185.4
Grand Average	**7.5**	**181.7**

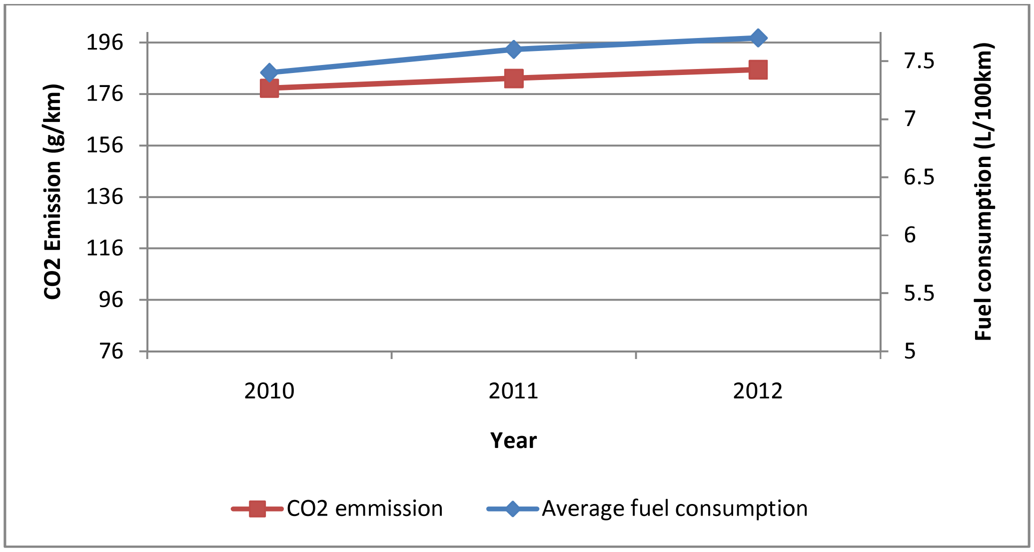

Figure 2-4: Trends in Fuel consumption and CO_2 emission over the period 2010 to 2012

Table 2-9: Average CO_2 Emission (g/km) for new and used vehicles

Year of Vehicle Registration	Average CO_2 emissions (g/Km)		
	New	**Used**	**Grand Average**
2010	172.9	178.3	178.2
2011	172.5	182.2	182.0
2012	168.4	185.8	185.4
Grand Average	**171.3**	**182.0**	**181.7**

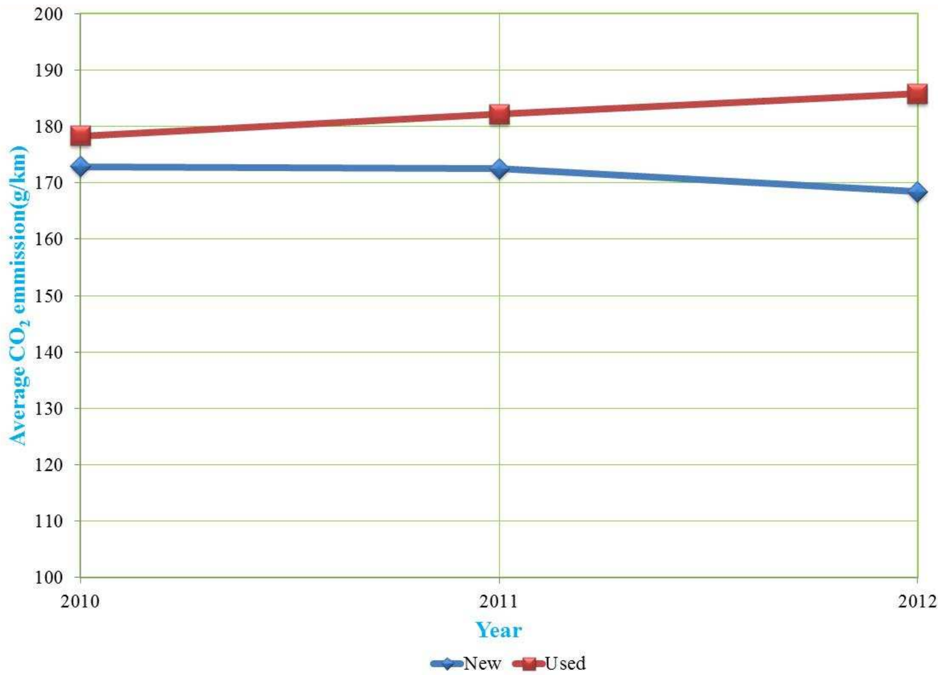

Figure 2-5: Trends in CO_2 emissions over the study period, 2010-2012 for new and used vehicles

New vehicles were observed to have lower CO_2 emission and fuel consumption as compared to used vehicles as shown in Table 2-9 and Figure 2-5 for CO_2 emission levels and Table 2-10 and Figure 2-6 for fuel consumption levels. The marginally improved performance of new vehicles was primarily attributed to improved technology and better mechanical condition of the vehicles.

Table 2-10: Average Fuel Consumption of combined test cycle (L/100km)

Year of vehicle Registration	New	Used	Grand Average
2010	7.0	7.4	7.4
2011	6.6	7.6	7.6
2012	6.3	7.7	7.7
Grand Total	**6.6**	**7.6**	**7.5**

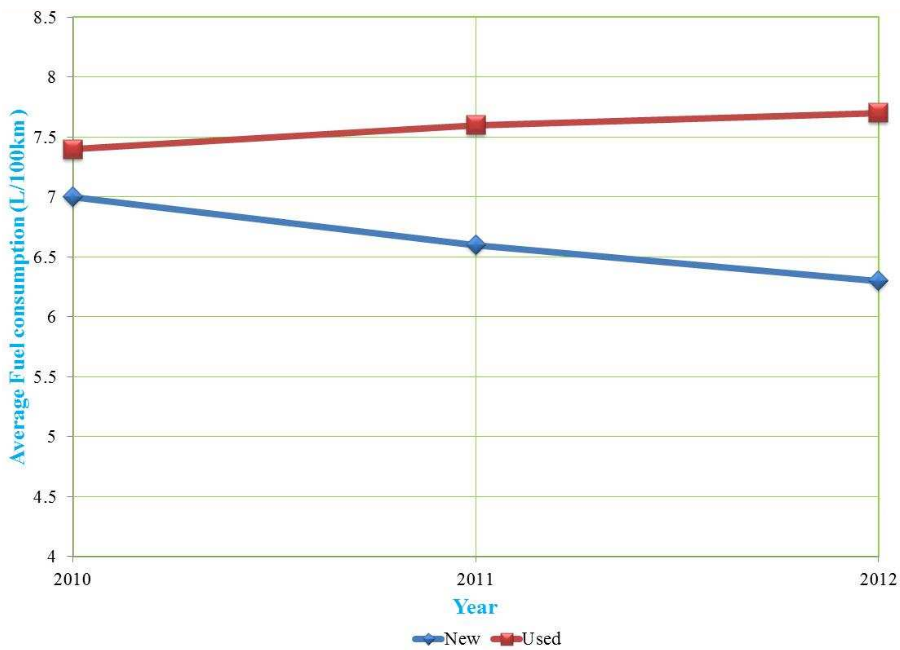

Figure 2-6: Trends in Fuel Consumption levels for new and used cars (2010-2012)

Vehicles with diesel engines were observed to have higher fuel consumption rates when compared to petrol powered vehicles. On average, diesel vehicles had an average fuel consumption of 8.0 L/100km while the petrol powered vehicles had an average of 7.4 L/100km of fuel consumption.

Technically however, a diesel powered engine gives lower fuel consumption than a petrol powered engine of the same engine displacement, on account of the higher amount of energy per litre in diesel fuel and the higher efficiency of the diesel cycle.

The observation of higher fuel consumption of vehicles with diesel engines was attributed to increase in popularity of larger heavier vehicles with larger engines in the form of Sport Utility Vehicles (SUVs).

Table 2-11: Average Fuel Consumption of combined test cycle (L/100km)

Year of vehicle registration	Fuel Type		
	Diesel	Petrol	Grand Average
2010	8.0	7.2	7.4
2011	7.9	7.5	7.6
2012	8.0	7.6	7.7
Grand Average	8.0	7.4	7.5

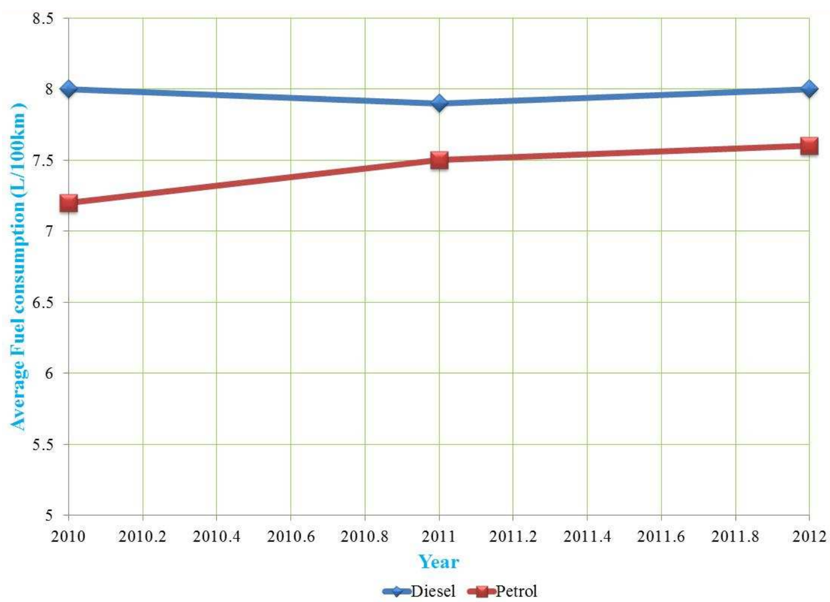

Figure 2-7: Trends of Average Fuel Consumption for Diesel and Petrol powered vehicles

Figure 2-7 shows the performance of diesel engine vehicles in comparison to those with petrol engines. The higher fuel consumption of diesel vehicles was attributed to increase in popularity of larger heavier vehicles with large engines in the form of SUV's. The fuel efficiency of diesel vehicles over petrol vehicles is however noted in Figures 2-8 and 2-9. The high engine capacity petrol cars consume almost double the amount of fuel compared to the same engine size for diesel vehicles.

Table 2-12: Fuel Consumption (Combined test cycle, L/100km) for diesel and petrol Engines

Engine Displacement								
Fuel Type/Year	0-1000	1001-1300	1301-1500	1501-2000	2001-2500	2500-3500	3500 +	Grand Average
Diesel	**0.0**	**6.8**	**6.5**	**7.0**	**7.8**	**8.0**	**9.8**	**8.0**
2010	0.0	6.7	6.6	7.3	7.7	8.1	9.6	8.0
2011	0.0	7.1	6.3	6.9	7.8	7.9	9.9	7.9
2012	0.0	6.4	6.4	6.8	7.8	8.1	9.8	8.0
Petrol	**5.6**	**6.5**	**6.4**	**7.2**	**7.8**	**8.7**	**13.5**	**7.4**
2010	5.5	6.3	6.3	7.2	7.6	8.5	13.2	7.2
2011	5.5	6.5	6.5	7.2	7.8	8.8	13.7	7.5
2012	5.7	6.7	6.5	7.2	8.0	8.8	13.6	7.6
Grand Average	**4.8**	**6.5**	**6.4**	**7.2**	**7.8**	**8.3**	**11.8**	**7.5**

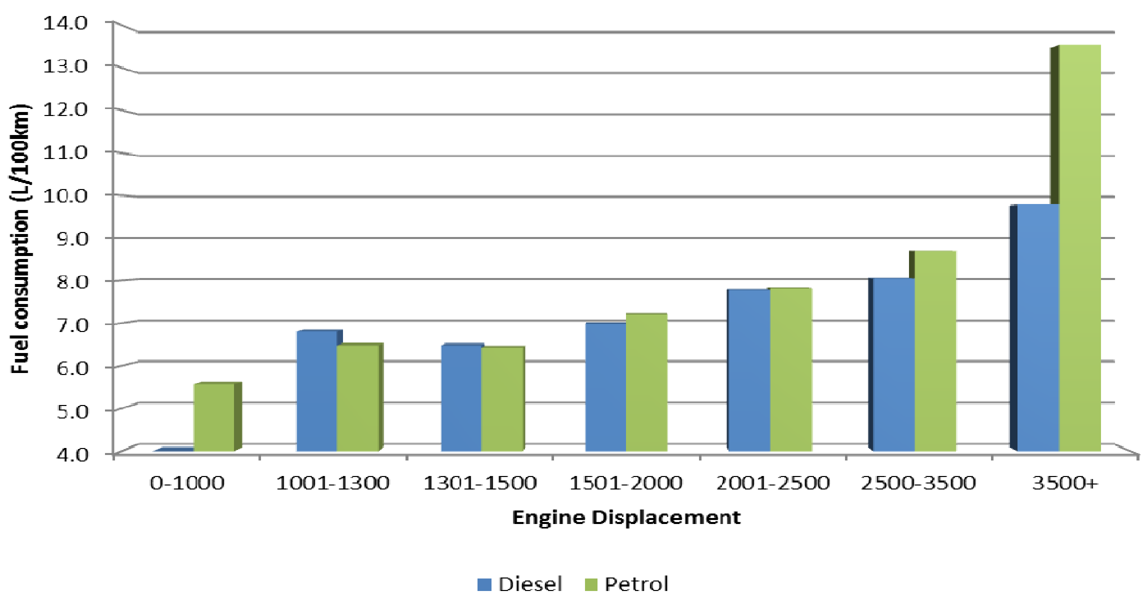

Figure 2-8: Fuel Consumption levels by fuel type and engine displacement

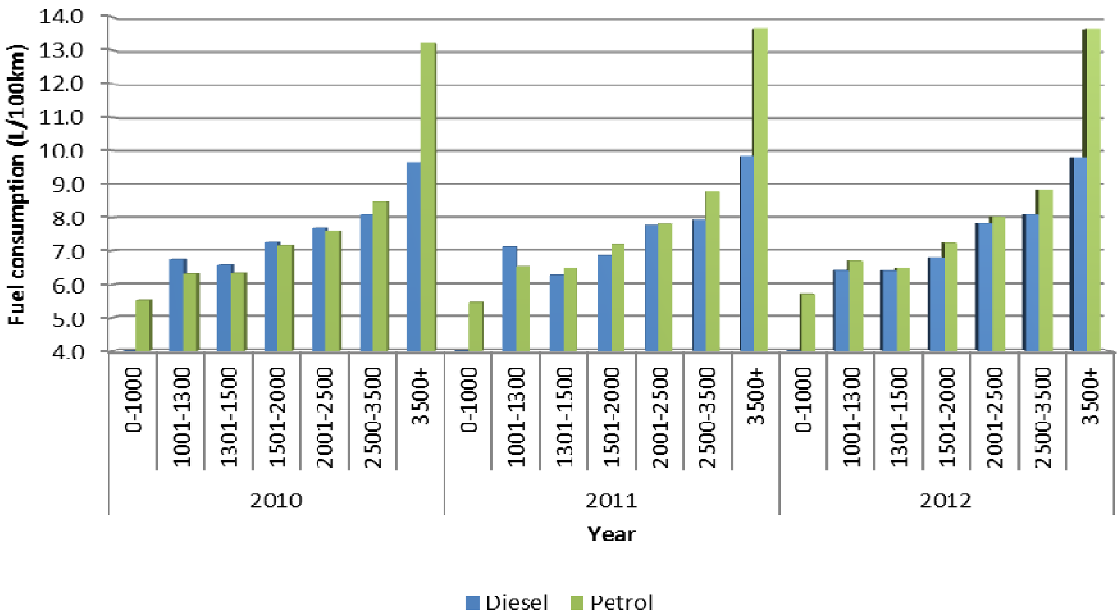

Figure 2-9: Average Fuel Consumption for Diesel and Petrol Engines by Vehicle capacity

Table 2-13: Fuel consumption (L/100km) by Tare Weight

Tare Weight (Kg)	Diesel	Petrol	Grade Average
0-1000	6.4	6.9	6.8
1001-2000	8.0	7.3	7.5
2001-3000	8.2	8.4	8.3
3001-3500	8.4	8.6	8.5
GRAND AVERAGE	**8.0**	**7.4**	**7.5**

Table 2-13 and Figure 2-10 show that tare weight (vehicle mass) is directly proportional to fuel consumption. A low tare weight is associated with low fuel consumption. Vehicle mass reduction can be achieved by replacing conventional steel in the bodies and engines of vehicles with materials that are equally strong but significantly lighter in weight. A 10% reduction in vehicle mass can improve fuel economy by 4-8%. (Inter Academy Council, 2007).

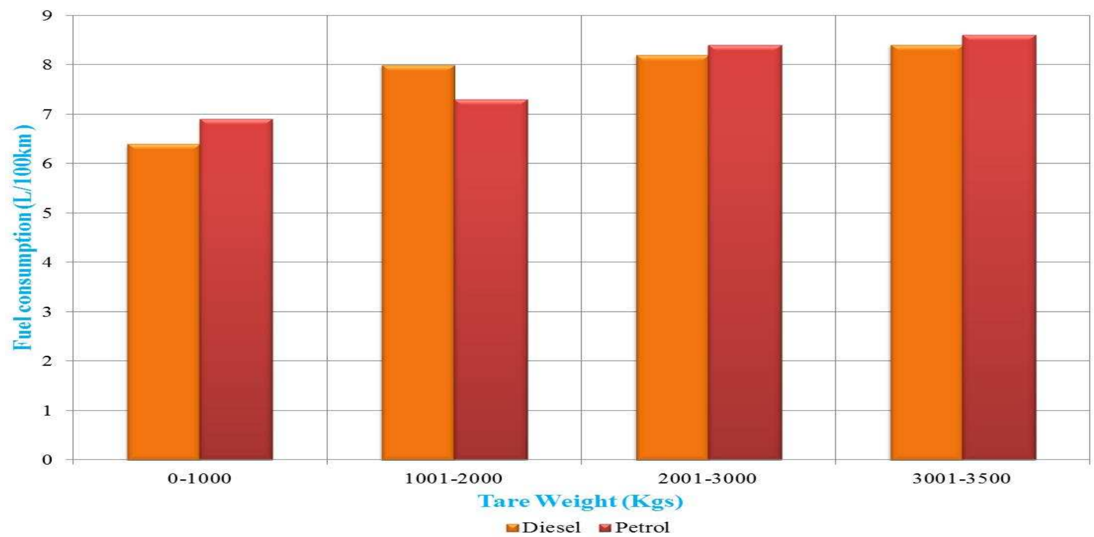

Figure 2-10: Average fuel consumption in L/100km by vehicle Tare weight

2.9 Average age of Registered Vehicles

Table 2-14 and Figure 2-11 give the number of vehicles registered in the period 2010-2012. A breakdown by the year of manufacture of the vehicles is also provided. This demonstrates the average age of registered LDVs on the roads. The country currently limits the age of vehicles for import to eight years and this confirms that the vehicles registered during the period of study conformed to the policy on age. Few vehicles of over eight (8) years that appeared in the registration were presumed to be re-registration after use by other institutions which may include United Nations, Military/Security and other special Government Departments.

Table 2-14: Vehicle registration (2010-2012) by the vehicle year of production

Year of production of vehicle	Numbers of vehicles registered
1970-1999	3,322
2000-2001	2,836
2002-2003	66,074
2004-2005	201,608
2006-2007	19,464
2008-2009	2,284
2010-2011	3,746
2012	760
Total LDVs	**300,094**

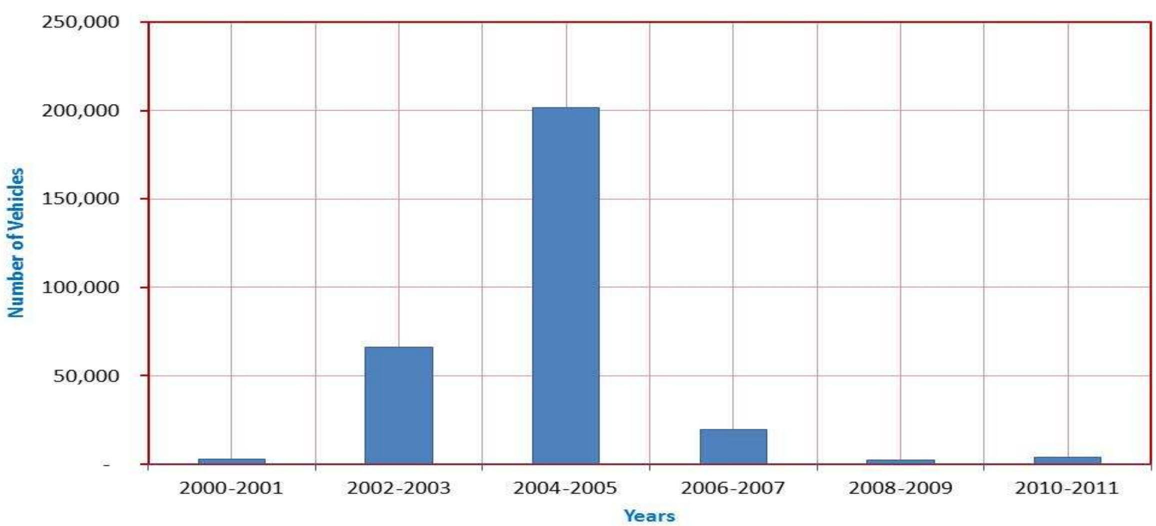

Figure 2-11: The number of vehicles registered and year of production

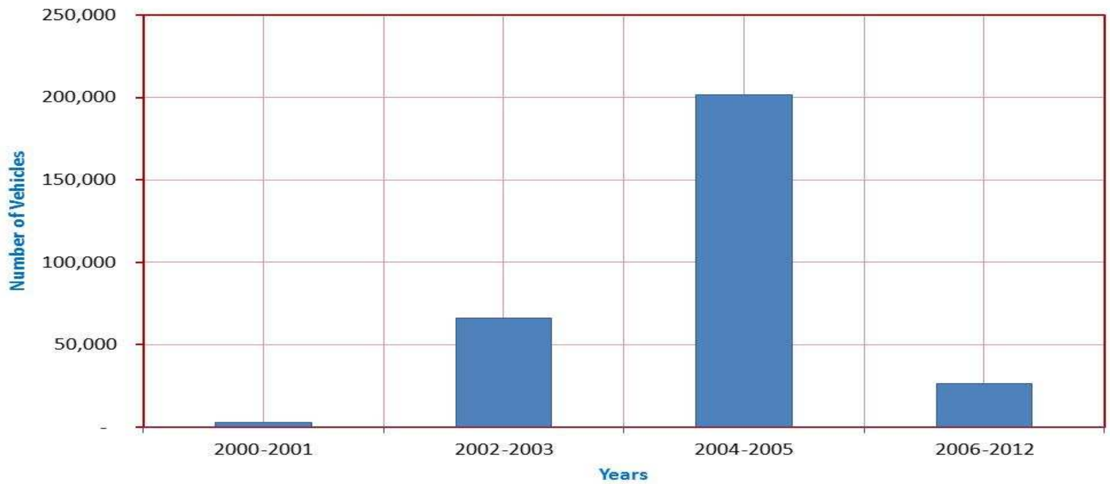

Figure 2-12: The number of vehicles registered and year of production

2.10 Make of Vehicles, their CO_2 and Fuel Consumption

Table 2-15, Figures 2-13 and 2-14 give the different makes of vehicle and their fuel consumption and CO_2 emission. Higher fuel consumption was observed for vehicles with large engine sizes, such as Land-Rovers and Lexus and lower fuel consumption and emissions observed for new vehicles such as Chevrolet and Opel. Since other performance parameters were not captured the difference was attributed to the engine capacities.

Table 2-15: Fuel consumption and CO_2 emission by vehicle make

Vehicle Make	Average Fuel Consumption (L/100km)	Average CO_2 Emission (g/km)
Lexus	10.36	244.72
Land Rover	10.32	262.69
Jaguar	9.18	220.29
BMW	8.80	215.89
Audi	8.17	205.56
Suzuki	8.15	199.07
Volkswagen	8.14	200.85
Mitsubishi	7.95	191.26
Nissan	7.63	186.99
Mazda	7.59	182.11
Subaru	7.59	180.07
Honda	7.51	176.21
Mercedes Benz	7.46	180.93
GM Chevrolet	7.41	178.42
Toyota	7.32	174.71
Peugeot	6.79	161.59
GM Opel Astra	5.57	137.72
Grand Average	**7.50**	**181.70**

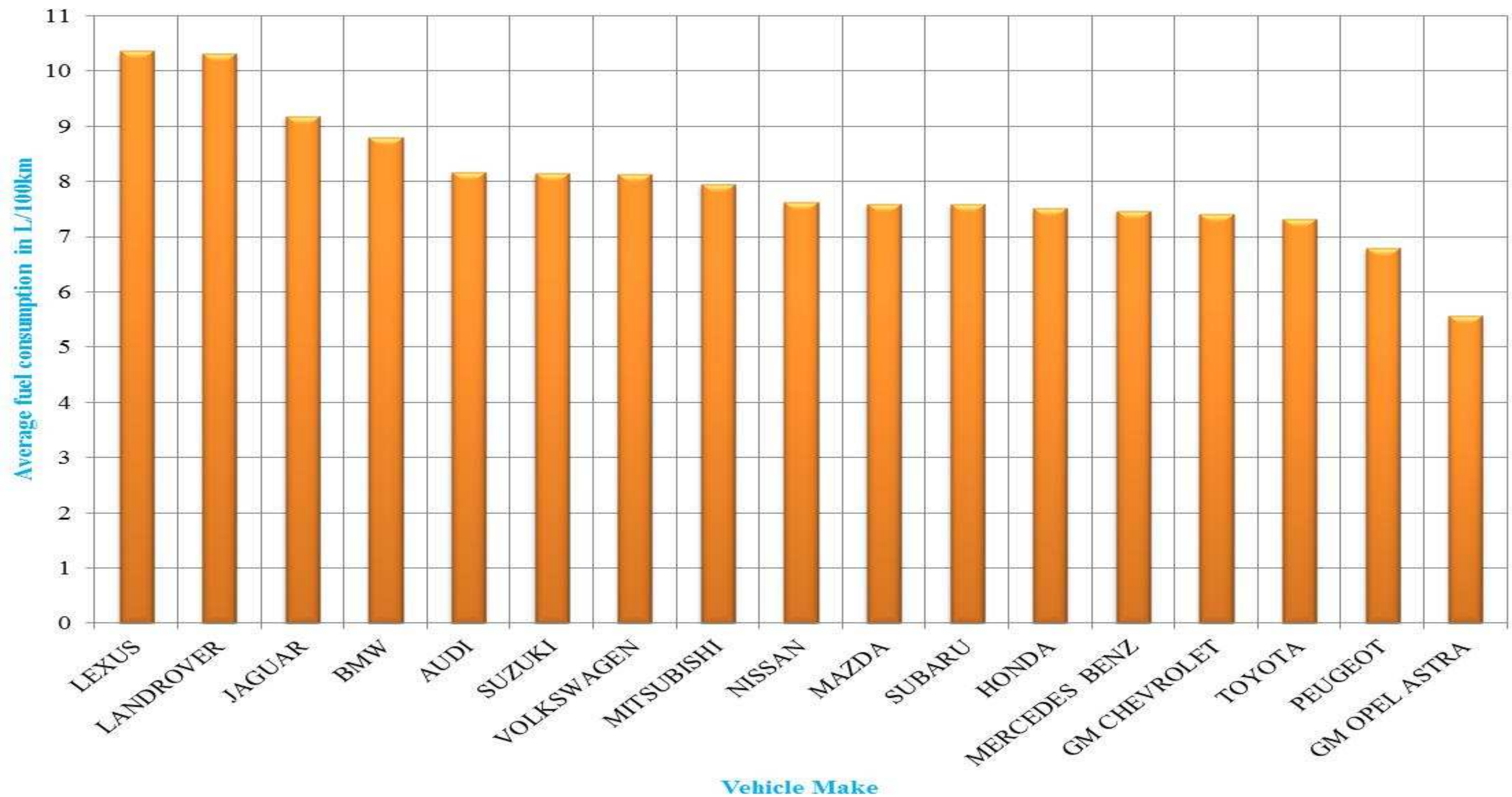

Figure 2-13: The average fuel consumption in L/100km by make of vehicle

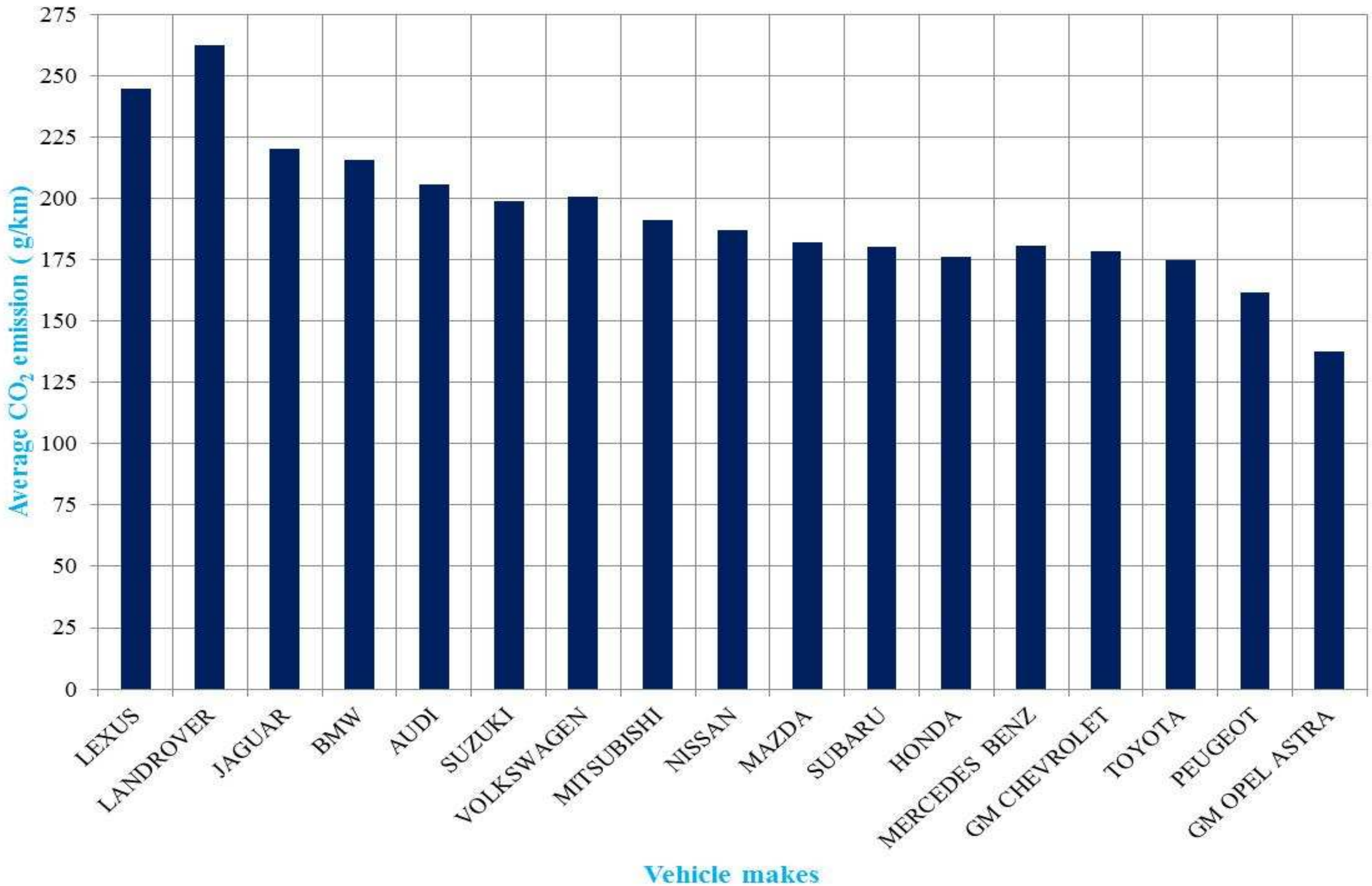

Figure 2-14: The average CO_2 emission in g/km by popular vehicle makes

2.11 Comparison of CO_2 Emissions in Kenya with Other Countries

Comparison of fuel efficiency from the study with that of American, European, Japanese and South Korean levels provided additional insight to the local situation. Japan and Europe were of primary interest due to the fact that almost 90% of used vehicles in Kenya were manufactured and initially used there. It was also noted that large Sports Utility Vehicles (SUV's) from America, Japan and Europe have increased in popularity and their presence could have an effect on the fuel economy. Data in Figure 2-15 and Table 2-16 were sourced from ICCT reports and local data was superimposed for comparison.

Table 2-16: CO_2 emission levels across countries (gCO_2/km)

Year	USA	Europe	Japan	Australia	Canada	China	S. Korea	Kenya
2002	260	165	158	210	243	210		
2004	258	163	152	203	230	200		
2005	256	162	150	198	226	195		184.2
2006	255	160	148	192	222	190	198.0	184.3
2007	253	155	145	188	216	184	198.5	184.5
2008	250	150	142	185	210	178	199.0	184.7
2010	245	140	140	178	190	165	199.0	178.2
2011	243	138	138				199.5	182.0
2012	240	135	135				200.0	185.4

Source: *Kenyan data is partly sourced from Climate XL/UNEP report*[4] *(2005, 2008), UNES study (2010-2012), and from ICCT reports*

[4]Methodological Guide to Developing Vehicle Fuel Economy Databases Prepared for the Transport Unit Division of Technology, Industry and Economics, UNEP by the Climate XL Africa.

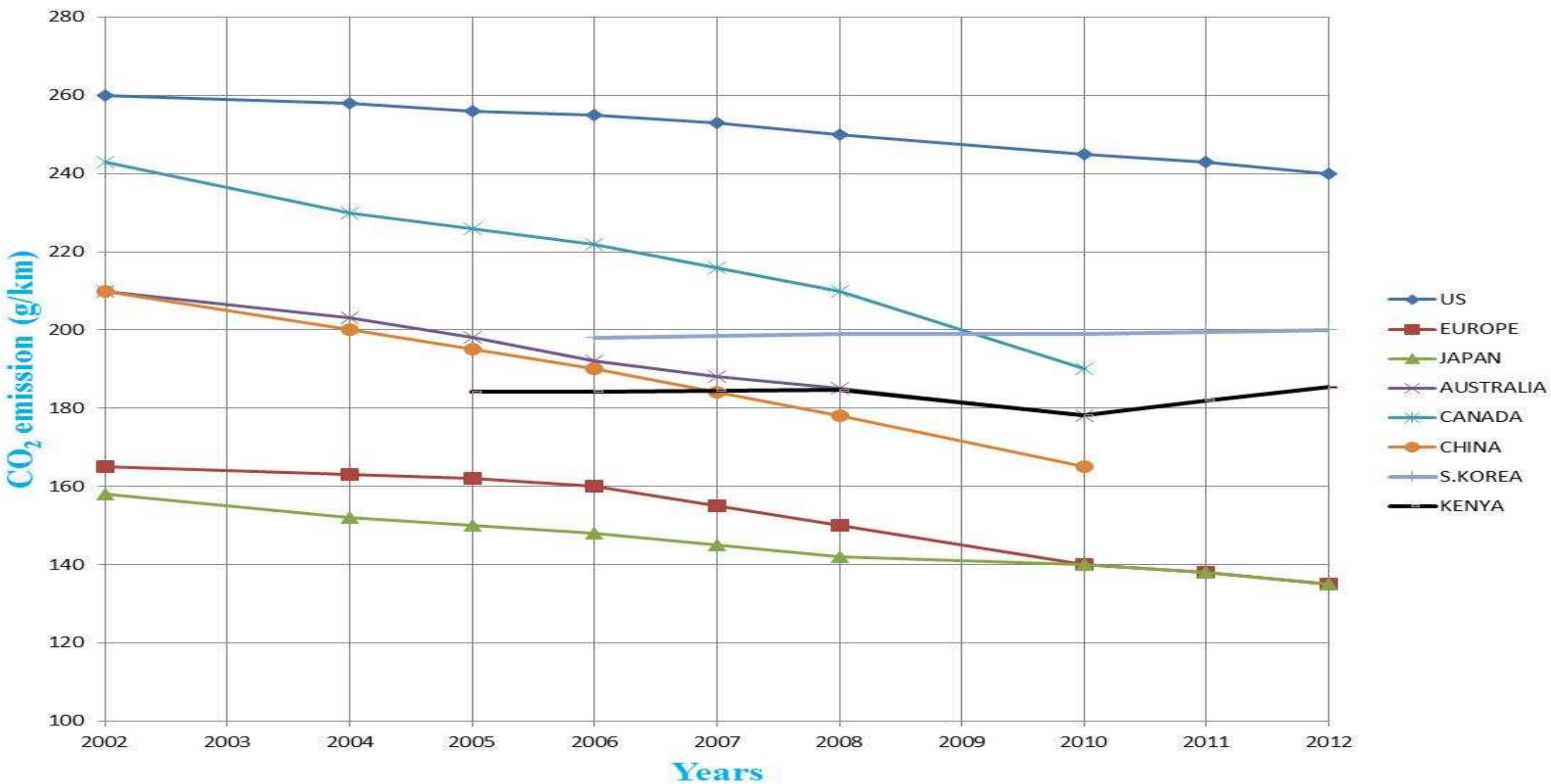

Figure 2-15: The average CO_2 emission in g/km for selected countries

Table 2-17: Fuel consumption levels across countries (L/100km, NEDC test cycle)

Year	USA	Europe	Japan	Australia	S. Korea	Kenya
2002	13.18	8.33	8.55	11.30		
2004	12.91	8.11	8.33	10.21		
2005	12.81	8.01	8.11	10.04		7.69
2006	12.66	7.72	7.72	9.89	9.89	7.65
2007	12.61	7.53	7.53	9.74	9.89	7.62
2008	12.51	7.36	7.36	9.59	9.74	7.60
2010	12.17	6.88	7.19	9.31	10.21	7.40
2011	11.94	6.73	7.11		10.21	7.60
2012	11.72	6.59	7.03		10.21	7.70

Source: *Kenyan data is partly sourced from Climate XL/UNEP report*[5] *(2005, 2008), UNES study (2010-2012), and from ICCT reports*

The average CO_2 emission levels for vehicles on Kenyan roads were noted to compare with that of Australia and China. Those of USA and Japan were observed to be at the extreme ends of classification, with the highest CO_2 emissions in the USA. This was attributable to higher capacity engine vehicles that dominate the American vehicle fleet. The trends for Japan and Europe are similar, comparable and have the lowest CO_2 emissions.

[5]Methodological Guide to Developing Vehicle Fuel Economy Databases Prepared for the Transport Unit Division of Technology, Industry and Economics, UNEP by the Climate XL Africa.

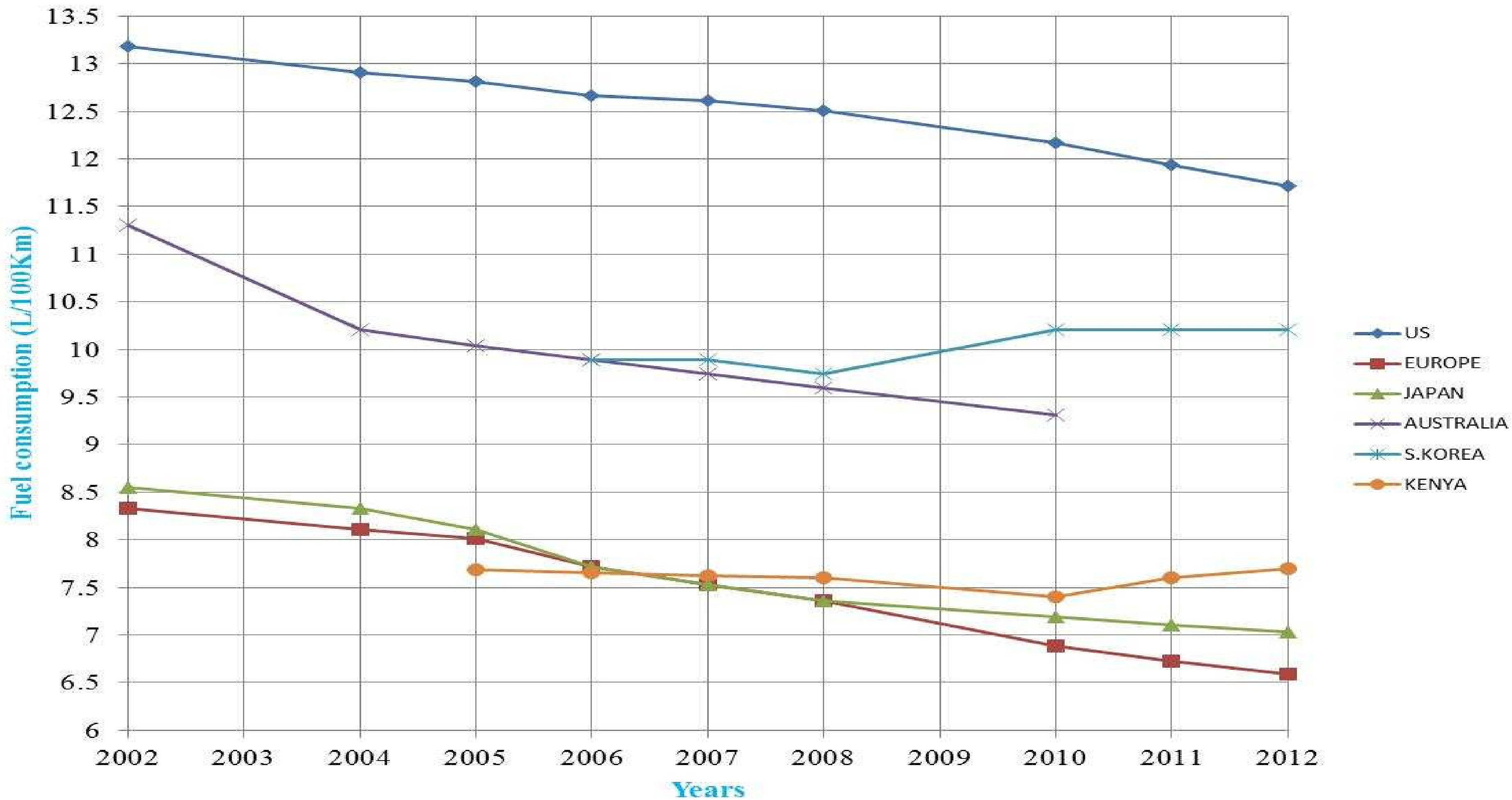

Figure 2-16: The average fuel consumption in L/100km for a select group of countries

According to Table 2-18 and Figure 2-17, about 80% of the LDVs imported into the country come from Japan. These vehicles enter the Kenyan market at an average age of 5 years as a result of the 8 year restriction on the age of vehicle import into the country. The observation of low fuel consumption figures for vehicle fleet in Kenya during the study period compares with the scenario in Japan around the years 2002-2004. This was interpreted that the vehicles which were new in Japan in 2002-2004 subsequently formed the bulk of imports into Kenya during the period 2010-2012. The local vehicle fuel efficiency is predominantly influenced by the source of vehicles in its fleet.

Table 2-18: Percentage of vehicle registrations by make

Vehicle Make	Total Numbers Registered	Percentage (%)
Toyota	216,568	72.2
Nissan	35,456	11.8
Subaru	10,412	3.5
Mitsubishi	7,072	2.4
Mercedes Benz	5,412	1.8
Mazda	4,196	1.4
Honda	3,762	1.3
Volkswagen	3,700	1.2
BMW	2,550	0.9
Others	10,966	3.7
Total	**300,094**	**100**

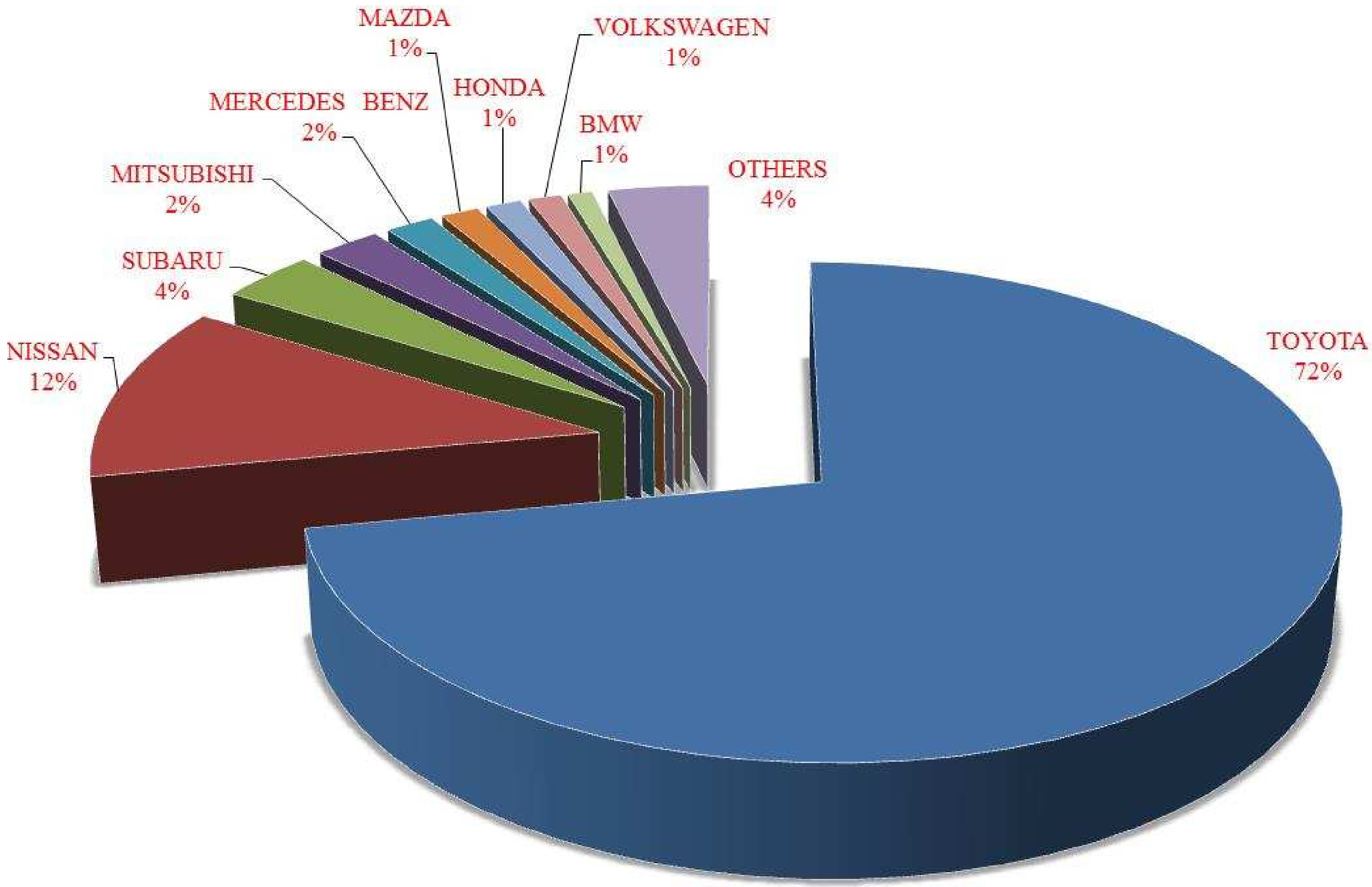

Figure 2-17: Percentage of vehicles on Kenyan roads by make registered during the period 2010-2012

2.12 Vehicle Technology and Infrastructure

The general trend worldwide is that there will be continued improvement on fuel economy and reduction in the average CO_2 emission. This is based on the following observations:

- Improvements in vehicle technology and engine design which encompasses increased uptake of hybrid powered vehicles, advanced engine technology, reduced rolling resistance and improved aerodynamics.
- Increased consumer preference for smaller Engine displacement vehicles.
- Continued growth in consumer acceptance of diesel powered vehicles.
- Improved infrastructure.

It is noted that reduction of CO_2 through vehicle technology alone can be more expensive than other measures like increasing use of bio-fuels, better infrastructure and traffic management and adoption of economic driving style (FCAI, 2011).

A comprehensive or integrated approach to reducing CO_2 emissions from passenger vehicles (reducing kilometers travelled, reducing the number of vehicles on the road and improving the entire vehicle fleet) will result in larger , cost effective CO_2 emission from road transport more than targeting vehicle technology(FCAI, 2011).

2.13 Hybrid Vehicles

Vehicles referred to as hybrid, use two or more power sources and currently the prominent ones combine an internal combustion engine and electric motors. Toyota Prius is the world's top selling hybrid vehicle and a limited number is in the databank of KRA. The numbers registered during 2010-2012 period is shown in Table 2-19. It is also noted that as of 2012 the Government exempted duty on all vehicles classified as hybrid.

Table 2-19: Hybrid (Toyota Prius) vehicles registered in Kenya (2010-2012)

Fuel Type	2010	2011	2012	Grand Total
Diesel	15,234	13,106	13,300	41,640
Hybrid (Prius)	40	22	26	88
Petrol	77,862	83,356	97,148	258,366
GRAND TOTAL	**93,136**	**96,484**	**110,474**	**300,094**

Table 2-20: Average of Fuel consumption (L/100km)

Year	Diesel	Hybrid	Petrol	Grand Average
2010	8.01	4.00	7.20	7.37
2011	7.89	4.00	7.51	7.58
2012	7.99	4.00	7.60	7.70
GRAND AVERAGE	**7.97**	**4.00**	**7.42**	**7.54**

The performance of hybrid vehicles as regards to fuel consumption and CO_2 emissions is the primary incentive as evidenced from Toyota Prius whose consumption is about 4.0L/100km and CO_2 emission of 92g/km.

Table 2-21: Average CO_2 emission (gCO_2/km)

Year	Diesel	Hybrid	Petrol	Grand Average
2010	211.65	92.00	168.85	178.16
2011	208.45	92.00	175.16	181.90
2012	211.44	92.00	176.19	185.35
GRAND AVERAGE	**210.74**	**92.00**	**173.12**	**181.70**

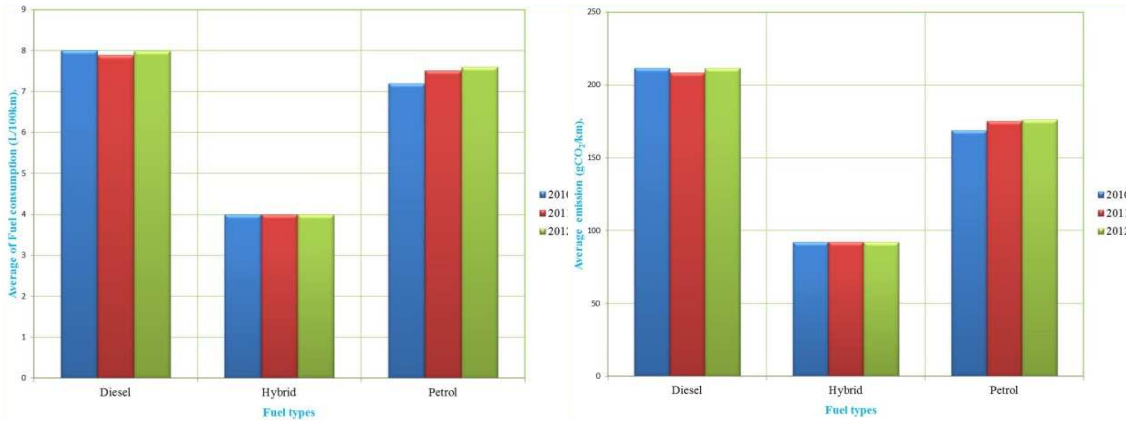

Figure 2-18: Average Fuel consumption (L/100km) and emission (gCO_2/km) depending on fuel type

2.14 Motorcycles Inventory

Since 2005 the number of motorcycles registered locally has manifested a phenomenal growth. This is attributed to their convenience and accessibility as motorized transport.

Though the percentage of motorcycles is less than that of Asian countries, every society experiences costs related to their presence. The costs are in the form of their contribution to deterioration of urban environment and increase in number of accidents. Figure 2-19 shows the dramatic and sudden change in the number of motorcycles registered during the period of study against LDVs.

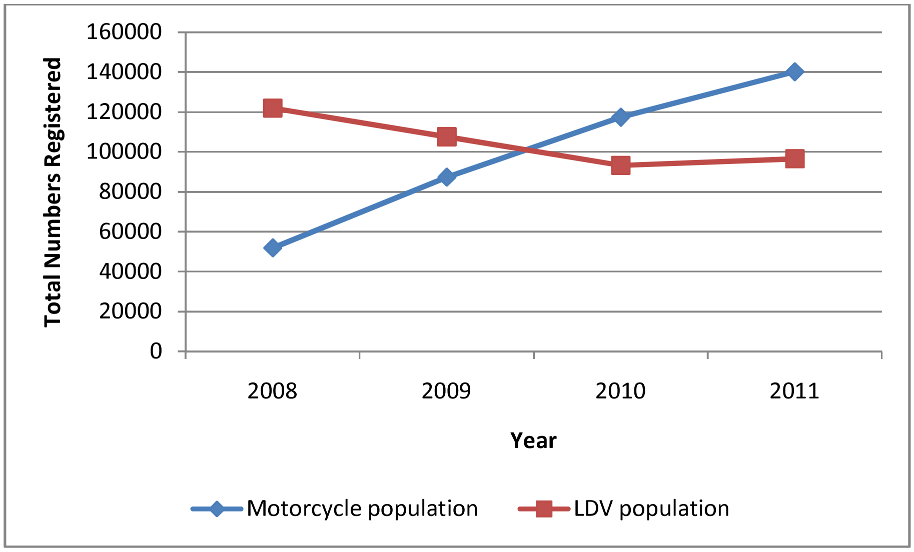

Figure 2-19: Number of motorcycles vis-à-vis number of LDVs in the period 2008 to 2011

2.15 Motorcycle Engine Technology and emissions

The motorcycle engine has traditionally been both two and four stroke types. The carbureted two stroke engines have been used where efficiency is not of primary concern and advantage can be taken of the simplicity of the engine which translates to lower cost and higher power per unit weight. Familiar examples where these are advantageous are for chain saws, outboard motors and motorcycles. The use in motorcycles is however on the decline on account of the engines poor emission characteristics.

The two stroke engines are in great part responsible for motorcycles disproportional air quality impact. The engines are highly inefficient in fuel consumption and much oil escapes from exhaust unburned. The exhaust is packed with oxides of nitrogen, oxides of sulphur, hydrocarbon and fine particles all of which are toxic contributors to air pollution and are detrimental to public health.

In a study carried out in Delhi, motorcycles were identified as the largest source of particulate emissions at busy traffic intersections and accounted for almost half of the emissions measured. It is generally acknowledged that, motorcycles are significant contributors of hydrocarbons, carbon monoxide and particulate matter. (Leapfrog Factor: Towards Clean Air in Asian Cities 2004).

Asian countries and other regions have begun to implement a combination of policies to reduce motorcycle emissions and increase customer preference for the more fuel efficient four stroke motorcycles. Though motorcycles with four stroke engines offer better fuel efficiency than the two stroke engine both types predominantly use carburetors which is responsible for high evaporative emissions through breathing losses and leakage through fuel lines/conduits. Evaporative emissions are predominantly hydrocarbons and the quantity in the air attributed to the motorcycle is higher than that from passenger cars.

The use of catalyst technology and other engine management systems are also not common in motorcycles. Though a variety of methods for reduction of pollution and fuel use are currently considered standard in passenger cars, the same have logistical constraints regarding application on motorcycles.

On the basis of the best available scenario, the emissions from motorcycles for a typical capacity below 150 cc are presented as in Table 2-22.

Table 2-22: Emissions from motorcycles of less than 150 cc

CO (g/km)	HC (g/km)	NO_x (g/km)	CO_2 (g/km)
2.623	**0.24**	**0.105**	**46.5**

Source: http://lat.eng.auth.gr/copert

2.16 Social Costs of Motorcycles

Extensive use of motorcycles is socially costly in that they contribute to deterioration of urban environment and increase the number of accidents. Potential approaches to reduction of these costs exist in ensuring the competency of riders, enforcing proper loading and maintenance. A prominent recommendation that partly addresses this is the need for periodical assessment of road worthiness.

2.17 Poor Quality of Urban Air

Vehicle emission is one of a number of contributing factors to poor urban air quality. In terms of the health impacts, four pollutants of particular concern are; particulate matter (PM), ozone, carbon monoxide and sulphur oxides (SO_x). These emissions depend very much on the fuels used and design of the vehicles.

The main contributor to lower emissions in developed countries has been the introduction of cleaner fuels concurrent with the introduction of improved engine technology and after treatment devices. Vehicles with petrol engines and equipped with catalytic converters emit more Carbon Monoxide and hydrocarbons than those with diesel engines. They emit virtually no particulate matter and produce more carbon dioxide per km. Emissions from vehicles with diesel are however higher in NO_x and particulate matter.

For petrol engines, the introduction of unleaded petrol has paved way for after treatment systems especially catalytic converters. For diesel vehicles, introduction of low-sulphur diesel fuels has made the introduction of after-treatment technologies possible. The current average emissions of HC, CO, PM and NO_X per km used in the study for petrol and diesel vehicles are as illustrated in Table 2-23.

Table 2-23: Average emission of HC, CO, HC, NO_X and PM

Vehicle	Carbon Monoxide CO(g/km)	Hydro Carbons HC(g/km)	Nitrogen Oxides NOx(g/km)	Particulate Matter (PM)(g/km)
Petrol	0.042	0.019	0.023	0.007
Diesel	0.002	0.003	0.031	0.07

Source: http://liftshare.com/content/stats.assumptions.asp

2.18 Sulphur Related Emissions

Sulphur is naturally present as an impurity in crude oil with actual amount varying between 10 ppm to more than 10000 ppm depending on location of crude oil source.

During combustion the sulphur is released as sulphur dioxide (SO_2) from both diesel and petrol engines and particulate matter from diesel engines. Sulphur reduces the effectiveness of vehicle emission control technologies for petrol and diesel, resulting in increased vehicle emissions of CO, HC, NO and PM.

There are a number of excellent technologies for control of emissions once diesel fuel has sulphur levels of 500 ppm or less. Lower levels of 50 ppm and less not only reduces particulate matter emissions but also enables the introduction of emission control technologies that provide even greater emission reduction. In Kenya, UNEP has supported the National Environment Management Authority (NEMA) and the Petroleum Institute of East Africa (PIEA) to promote low Sulphur diesel, a move that led to imported diesel standards being lowered from 5000 ppm to 500 ppm (Introducing Low-Sulphur Fuel in East Africa, 2010).

2.19 Findings and Discussions

1. No simple statement indicating preference is possible between the petrol and diesel engines. The only promising and feasible method for reduction of pollution is the use of cleaner petrol and diesel. It is cheaper to improve convectional fuels as no investment is needed for new storage tanks and service stations. Further reduction of sulphur in both petrol and diesel fuels is one of the effective methods for improvement of air quality.
2. Regular inspection and maintenance standards need to be enacted and enforced for all LDVs. This will include vehicle emissions monitoring.
3. Enforcement of vehicle maintenance and inspection standards would improve road safety. Inspection programs should include private vehicles.
4. Reduction of CO_2 through vehicle technology can be more expensive than other measures like increasing use of biofuels, better infrastructure and traffic management and adoption of economic driving style.
5. A comprehensive or integrated approach to reducing CO_2 emissions from passenger vehicles (reducing kilometers travelled, reducing the number of vehicles on the road and improving the entire vehicle fleet) will result in

larger , cost effective CO_2 emission from road transport more than targeting vehicle technology.

6. Potential approaches to reduction of the costs associated with motorcycle usage exist in ensuring the competency of motorcycle riders, enforcing proper loading and maintenance. A prominent recommendation that partly addresses this is the need for periodical assessment of road worthiness.

2.20 Conclusions on Vehicle Inventory

1. The vehicle registration database was used to carry out projections for the year 2030 and on the basis of the best line of fit; the projected registration for a fleet of LDVs would be approximately 300,000 per year. In a similar manner the projected cumulative total vehicle population in 2030 would be approximately 5 million. Though the best line of fit does not cover all the variables which influence such projections for example political and economic issues; in its simplicity it projects a potential environmental challenge.
2. Petrol engines were established as most prevalent with the preferred engine displacement in the range of 1300 to 2000 cc.
3. The absence of prominent contribution from electric/hybrid vehicles was considered unusual and was attributed to insufficient general public awareness of fuel efficiency issues.
4. The sudden increase in the number of motorcycles was attributed to their convenience and accessibility as motorized transport. The typical costs related to their presence namely their contribution to deterioration of urban environment and increase in number of accidents highlighted. The use of two stroke engines in motorcycles is on the decline on account of poor emission characteristics and high fuel consumption. Numerous countries have actually implemented policies to reduce prevalence of the motorcycles with two stroke engines. The engine is considered unfriendly to the environment and generally recommended for reduced production. Countries that do not manufacture the motorcycle (2-stroke) should restrict its importation to minimize detriment to the environment.
5. Extensive use of motorcycles is socially costly in that they not only contribute to deterioration of urban environment but also increase the number of accidents.
6. Diesel engines produce less CO and HC, have greater fuel economy and produce less CO_2 per km. However recent health concerns about Particulate Matter (PM) have given diesel a less environmentally friendly image as have the higher emission of Nitrogen Oxides compared to petrol cars. Petrol engines produce virtually no PM, produce more CO_2 per km and have higher emission of the regulated pollutants.

3 REGULATIONS AND STANDARDS

3.1 Legal Framework

The Kenyan Constitution has enhanced protection and enforcement of fundamental rights amongst other gains. Under the Constitution every person is entitled to a clean and healthy environment.

There exist several regulations and incentives to promote cleaner and fuel efficient vehicles on emissions, inspection, catalytic converters and other technologies, taxation and fee bates. These issues are addressed via the law governing:

3.1.1 The Environmental Sector

While it may be difficult to point out the exact contribution that vehicular emissions have on health due to the resulting air pollution, it is evident that these emissions contribute hazardous air pollution. This is one of the reasons that necessitate an interrogation of the regulations that have so far been adopted to address or at the bare minimum, mitigate this vice.

The right to a clean and healthy environment has been provided for in a variety of legal instruments [both international and national – constitutional and legislative] and in interrogating the extent towards which this right has been advanced in these instruments, attention has been paid to the stringency of the regulatory platform currently in place in Kenya as well as the tenor of the Air Quality Guidelines in a bid to rein in on hazardous vehicular emissions and meet the prescribed GFEI initiatives.

3.1.2 The Transport Sector

In addition to the discussion above under regulations in the environmental sector, it is equally important to interrogate provisions that inform inspections, registration and licensing of motor vehicles, the institutional framework in place to assist in this initiative, the imposition of stringent penalties in cases of non-compliance as well as the established Standards that guide the regulation of the Transport sector. In the context of the above discussion, attention has been paid to the relevant provisions that address the challenges of vehicular emissions and the extent towards which these provisions are critical to the achievement of that initiative.

The laws that have been established to regulate the transport sector in the country include:

a) Traffic Act, Chapter 403

This law mandates the registrar of motor vehicles to keep track of all motor vehicles and trailers registered in Kenya. Section 51 of the law stipulates that all vehicles of more than 4 years from the date of manufacture should be subjected to inspection by the Motor Vehicle Inspection Unit. The act also provides for existence of inspection centers throughout the country.

b) Integrated National Transport Policy, 2009

Section 14 of the act proposes the use of lead free and low sulphur fuels. The act stipulates the domestication of efficient and less polluting fuels. It also provides strategies of dealing with the Public Service Vehicles as far as proper maintenance, gas and noise pollution are concerned.

c) National Transport and Safety Authority (NTSA) Act, No. 33 of 2012

The act provides for the establishment of the NTSA body, whose functions are to spearhead the implementation of policies in the road transport sector, as stipulated in section 4 of the act. The functions of NTSA include registration, inspection and licensing of motor vehicles.

d) Standards Act, Cap 496

The prominent standards are:

(i) KS 1515:2000 – Code of practice for inspection of road Vehicles

Stipulates that vehicles should not emit visibly colored smoke, the concentration of carbon monoxide (CO) should not exceed 0.5% by volume and hydrocarbons should not exceed 0.12% by volume.

(ii) KS 2060:2007 – Motor Gasoline Specifications

Specifies that the maximum lead level should be 0.015g/L and maximum sulphur level should be 0.15%.

(iii) KS 1309-1:2010 – Diesel Fuels: Specification

This act specifies the maximum requirement of fuel Sulphur content at 500 ppm.

(iv) KS 03-1099:1992 – Specification for Engine Oils

Specifies maximum requirement of sulphur content as 0.05%

The limitations and impact of these and other existing regulations are determined by the process of enforcement and implementation as it is possible to create a great deal of positive impact in the transport sector in a relatively short time

3.1.3 The Energy Sector

In this respect, the regulations on licensing, importation, refining, exportation, wholesale, retail, storage or transportation of petroleum, or sale of adulterated petroleum, inspection of petroleum with prescribed apparatus as well as policy initiatives in the Energy Sector that are critical to the realization of reduced vehicular emissions have been considered.

3.1.4 Tax Provisions

Consideration is also accorded primarily to the existent taxation provisions for the importation of motor vehicles as well as the taxation of petroleum with a bid to appreciate the tenor of incentives that may or may not exist in legislation on tax.

3.2 Benchmarking Kenya Emissions Standards against International Best Practices

Most of Kenyan legislation appertaining to the sustenance of the environment by the limitation of harmful emissions into the environment is restrictive or prohibitive rather than proactive. Kenya's development in the transport sector in the last 3 years is well known, where road transport is concerned. There have been various proposals on the limitation of the 14 seater *matatu* to be replaced by the 25 seater mini-van. Even then, documentation remains scanty on legislative action to actively combat any GHG emissions. Kenya's Vision 2030 acknowledges the need to mitigate climate changes via monitoring emissions on road traffic. The National Climate change action plan (NCCAP) encapsulates Kenya's measures.

Among the 7 measures evaluated to counter emissions especially in the urban areas was the Bus Rapid Transit (BRT) Corridors complimented by the Light Rail Transit (LRT). The use of bio-fuels was identified as beneficial to the country such that it would aid in lowering GHG emissions however, its large scale production, if poorly planned, would mean competition with food production. The following are the raft of measures that the NCCAP envisages;

a) Employ more effective traffic management technologies, especially traffic control lights to reduce vehicle travel time mainly in urban areas.
b) Introduce vehicle emission control technologies, such as the installation of catalytic converters in the vehicle exhaust pipes to reduce gaseous emissions.
c) Enhance vehicle inspection regulations to include personal cars and also to enforce emission controls.
d) Formulate a regulatory and economic framework that will lead to reduction of old inefficient vehicles from the roads.
e) Transfer and deploy technologies for solar energy-driven small vehicles. Hybrid vehicles that use both solar and fossil fuel energy are good examples.
f) Up-scale mass transport systems to reduce the use of personal vehicles. In this regard, bus rapid transit technologies need to be actively promoted and

should include financial incentives and modification of road infrastructure to create enabling conditions for their operations.

g) Promote technologies for manufacturing light-weight non-motorized hand carts to enhance their maneuverability.

The preceding proposals present us with a road map for us as a country, however it is not comprehensive enough especially in light of climate change. Instilling legislative measures that will mirror international best practices will properly suit especially within the realms of technology. In this regard, it is imperative that we benchmark against initiatives best demonstrated in Countries such as; USA, EU on regional approach and from Africa: South Africa, Mauritius and Egypt whose regulations and policies have been instructive in the reduction of emissions.

3.3 Challenges in Implementation of Existing Legal and Regulatory Framework

The existing institutions in the transport sector faces challenges in undertaking their legal mandate, coupled with challenges in the existing legal framework the transport industry faces difficulties in implementation of vehicle emission reduction strategies.

There is a limited understanding of the extent and morbidity of the problems among the public and policy makers from the laws passed dealing with emissions. Effective integration of environmental policies into the larger population like any good law requires improving awareness of environmental problems among both the public and policymakers. The public should be educated on the effects of air pollution on human health, climate change and on ways of reducing air pollution.

Environmental awareness has not received high attention and priority for many decades. Lack of capacity, poor coordination and linkages, documentation, utilization and preservation of indigenous knowledge are some of the challenges affecting environmental information and networking at community, civil society, private sectors, learning institution, government institutions and international levels. There is need to develop nationwide environmental awareness programs.

3.3.1 Inadequate Inter-Sectoral Mechanisms

Implementation of environmental laws requires cooperation and collaborations of various institutions from different sectors of the economy. Although NEMA, NTSA, KEBS and ERC have in the past worked together in motor vehicle inspection and testing, there is lack of adequate mechanism to ensure that these institutions together with the Kenya Police Service fully cooperate and collaborate to ensure that provisions of the law on vehicle emissions are fully implemented. This calls for an improved inter-sectoral coordination within the policy level. The government should establish and strengthen road agencies, build capacities in the roads sub-sector and involve stakeholders at all levels of transport development and in policy development.

3.3.2 Inadequate Resources

The existing government institutions, that enforce laws relating to environmental management in transport sector lack adequate facilities and equipment to effectively carry out their mandates. These institutions include the MVIU which has 19 motor-vehicle testing centers nationally. The agency has inadequate emission testing equipment and facilities to undertake tests on all vehicles used in the country. Although the unit should license environmental assessors they also lack adequate staff and offices across the country. Other institutions that have the same challenges include NEMA, KEBS and ERC.

3.3.3 Data Organization and Accessibility

Data on vehicles, vehicular emissions and air quality need to be organised and accessible. Although data collected nationally (by government institution and licenced environmental inspectors) maybe insufficient such data is not aggregated and cannot be easily accessed by policymakers or other practitioners. Tools are needed to reform the data collection and distribution processes. Currently there is no reliable database on active vehicle population. While new vehicles may be registered, vehicle retirement is often not recorded, making it difficult to identify which vehicles are still on the road. The lack of data on vehicle emissions is a challenge to be solved through policy. Thus, there is need to collect more parameters of vehicles imported and tested in Kenya.

3.3.4 Inspection of Motor Vehicles

Further to the provisions that have been discussed above on transport, there should be an imposition of mandatory annual requirement for emissions tests on all motor vehicles as this would be critical in ensuring that emission standards are upheld. Alongside this initiative, select garages could be trained, equipped and empowered to conduct this exercise by National Transport and Safety Authority (NTSA). This system has been adopted in the United Kingdom through Ministry of Transport (MoT) testing of every motor vehicle annually [and not just via testing upon importation or vide random road side testing] with significant success.

3.3.5 Lack of Inter-Modal Integration

In Kenya, each mode of transport operates largely on its own without deliberate logistic linkages between origin and destination involving different transport modes. There are clear gaps in Kenya's inter-modal infrastructure and the transport logistics chain. These act as constraints to optimal utilization of the transport systems. It is therefore necessary to ensure inter-modal connectivity among the various transport modes. For example Railway transportation should be developed for intermodal Linkages to Airports, Ports and Road Transport to strengthening regional, interurban and interurban infrastructure. Efficiency in the transport network will reduce fuel emissions. Furthermore closer inter-modal consultation, coordination and harmony will ensure optimal use of resources and reduce or eliminate duplication.

3.4 Gaps in the legal and regulatory framework

The legal framework that caters for government regulations and incentives to promote cleaner and fuel efficient vehicles is not perfect as it bear several gaps including:

3.4.1 Lack of an Adequate Urban Transport Policy

Kenya lacks an adequate urban transport policy. As such, there is no clear decision as to which modes of transport and facilities that the urban areas should encourage or provide. The existing legal and institutional framework is fragmented and uncoordinated for regulation, coordination, development and management of road passenger transport services. The Acts to regulate operations are inadequate. This has resulted to disorganized passenger transport operations, poor enforcement of regulations and lack of clear institutional guidelines to foster private sector participation.

The development of a proper urban transport policy should aim at developing an integrated, balanced and environmentally sound urban transport system in which all modes efficiently play their roles. Although the proposed Nairobi Metropolitan Region Bus Rapid Transit System and the development of a light rail for Nairobi and its suburbs under Vision 2030 are meant to address this problem for Nairobi, there is a need for an urban policy for all cities, towns and other urban centers in the long term.

The government should establish a Metropolitan Transport Authority (MTA) to handle intra-urban regulatory issues (except licensing) in major urban areas and management of urban transport services. An autonomous Metropolitan Police (recruited by MTA; trained, accredited and regulated by the (MTA) to enforce the Traffic Act in urban centres.[6]

3.4.2 Lack of Policy Frameworks on Biofuel Development

The push towards cleaner energy sources and increase in fuel prices has created an urgent need to shift from high-cost fossil oil to cost-effective biofuel. Currently, there are several bio-fuel and particularly biodiesel, activities in Kenya, with NGOs such as Green Africa Foundation and Vanilla Development Foundation leading the way[7].

[6] Reference: Integrated National Transport Policy, May 2009

[7] Reference: Policies and regulations affecting biofuel development in Kenya, By Benard O. Muok, ShadrackKirui, Daniel Theuri and Judi W. Wakhungu, December 2008.

However, the development of bio-fuel in Kenya is currently hampered by lack of policy frameworks.

Though there are some initiatives being undertaken by the government to develop a policy framework for biofuel development, much remains to be done to develop regulations and standards that will promote and regulate the biofuel industry in Kenya. The biofuel industry cuts across several sectors that are governed by different policies all of which need to be harmonized to speed up the industry in the light of sky-rocketing fossil fuel prices.

3.4.3 Lack Adequate Standards and Specification

Kenya Lack standards and specifications for vehicle imported into the country. There are numerous makes and models of vehicles with various specifications leading to early scrapping of vehicles due to lack of spare parts, PSV and other commercial vehicles emitting higher GHG than recommended. The GoK should establish and enforce standards and specifications of vehicles for all vehicle categories according to their use. Mandatory regular inspection of all vehicles before licensing should be carried out. The government should also make it mandatory that all diesel engine vehicles be fitted with catalytic converters in the vehicle exhaust pipes to reduce gaseous emissions.

The Standards that provide for the permissible levels of toxins in the vehicular emissions should be reviewed with a view of reducing the levels of permissible toxins by taking into account the;

a) Global standards as well as benchmarking with international best practices;
b) Objective to reducing emissions as per the GFEI initiatives; and
c) Need to embrace technologies to aid in the achievement of the aforementioned objectives.

3.4.4 Lack of Law to Reward use of Fuel Efficient Vehicle

The Kenya taxation policy does not reward importers of fuel efficient vehicles. Although there is an age limit on second hand cars imported to the country, the duty payable on the importation of a motor vehicle is independent of vehicle fuel efficiency. To encourage importation of fuel efficient vehicles, countries have developed excise duty based on CO_2 emission for vehicles. As per such laws CO_2

levy is chargeable if the vehicle emission exceed a set threshold, or a CO_2 rebate is granted, if the vehicle emit less than the threshold. The current tax incentives are not aligned with the objective of reduction of the hazardous emissions from motor vehicles. For example, the Kenya Revenue Authority has a Duty Calculator which it relies on to calculate the duty payable subject to the modalities described here-in and more particularly subject to the Cost, Insurance and Freight (CIF) which is usually higher if the vehicle is newer as opposed to if the vehicle is older. Technically speaking, newer vehicles emit less hazardous emissions as compared to older vehicles therefore if the objective of reduction of the hazardous emissions from motor vehicles is to be achieved, then the amount of taxes levied should be revised to address this anomaly. If this was to be done, then newer vehicles would be imported in greater numbers [as opposed to the status quo where older vehicles are imported because the duty amounts levied on them are lower] and the general objective identified above would be met.

The other consideration that has not been taken into account under the tax laws save for the directive on tax exemptions for battery powered vehicles is that of reduction of the amount of duty levied based on the level of emissions per motor vehicle. This is only addressed to the extent that vehicles with bigger engines generally attract more in the amount of duty levied but it does not take into account the technologies that vehicles have e.g. catalytic converters as a litmus test to determine the amount of duty payable. Therefore, older cars and those with hazardous emissions will be imported *en masse* thereby defeating the intended objective.

3.4.5 Lack of Laws to Promote Less Polluting Fuel

The tax provisions on petroleum products should also take into account the hazardous effects from emissions that these products have on the environment. If this measure were to be used as the adoptive standard, then those products that are most hazardous to the environment would be the most highly taxed while those that are least hazardous would be subsidized thereby incentivizing the persons that transact in these products as well as the consumers of this products to embrace those that are less hazardous.

3.5 Conclusion and Recommendation

The report has listed the relevant areas addressed in legislative provisions that are key in the reduction of vehicle emissions in Kenya in various contexts including: environmental, energy and transport. In each of these key areas the report has widely reviewed the existing laws and regulations. In addition, cases of international best practice have also been highlighted to aid in benchmarking against the local standards in Kenya. From the discussion generated in this report, the preliminary finding is that there indeed do exist rules and regulations in the various contexts alluded to above which are key to aiding in reining on extensive vehicular emissions. This notwithstanding, the report has identified challenges that exist which curtail the efficacy of the legal provisions and it is important for these challenges to be acknowledged and addressed within the framework of the recommendations enumerated in Annex L.

4 HEALTH IMPLICATIONS RELATED TO THE TRANSPORT SECTOR

4.1 Introduction

The Non-Communicable Diseases (NCD) including air pollutants related diseases are emerging as the leading cause of death in developing countries (Mayosi *et al.*, 2009*)*. Outdoor air pollution has been noted to be leading cause of cardiovascular and respiratory illnesses (WHO, 2012). It is estimated that about 800,000 people die prematurely each year worldwide from poor urban air quality and most of these deaths occur in developing economies. In the year 2005 urban outdoor air pollution was estimated to cause 1.3 million deaths worldwide per year (WHO, 2005). Recently, outdoor air pollution was estimated to cause 3.7 million premature deaths in urban and rural areas worldwide (WHO, 2012).

It has been estimated that 90% of urban air pollution in rapidly growing cities in developing countries is attributable to motor vehicle emissions (UNEP, 2010). Generally, there are many sources of air pollution including: open air burning of refuse and biomass; industrial operations and domestic cooking fires, however, motor vehicles play a critical role in the problem (Kinney *et al.*, 2011). Based on this knowledge, it follows that considerable amount of non-communicable cardiovascular and respiratory illnesses would be attributable to air pollution from vehicle emissions.

The air quality in developing countries will continue to deteriorate as vehicle traffic grows. Consequently, these will have a drastic effect on economies and health with the highest impact being on vulnerable residents mostly pedestrians, women, children who live, walk, play and work in urban areas, especially near busy roads.

It has been estimated that 90% of urban air pollution in rapidly growing cities in developing countries is attributable to motor vehicle emissions (UNEP, 2011) and previously UNEP, projections indicate that it is possible to improve average fuel economy of new cars in OECD countries by about 30% by 2020 and 50% by 2030 at little or negative cost considering fuels savings (IEA 2008; GFEI (2010). The effects of pollutants into air, water and land, intentionally or accidentally, negatively affects people's health and as well as the environment. In view of this Environmental Management and Coordination Act (EMCA), 1999 in Kenya mandated the establishment of a National Environment Management Authority (NEMA). Previous survey in Nairobi have shown that the black carbons (BC) concentrations were comparable to those recorded in some of the world's Mega Cities though Nairobi has a population of less than 10 million inhabitants (Gatari *et al.*,2009)

A strong correlation has been demonstrated between fine particulates and vehicle density in Kenya implying that motor vehicle emissions remain a source of fine particulate matter (Odhiambo *et al* ., 2010) and earlier study in Nairobi reported high levels of $PM_{2.5}$ and BC concentrations measured in the central business District and along Thika Road (Van Vliet and Kinney 2007) . According to KNBS 2007, most of newly-registered vehicles in Nairobi are imported as used vehicles from East Asia with a maximum age of eight (8) years. Due to affordability of the second hand vehicles there is increasing road congestion with high proportion of poorly maintained vehicles contributing to high particulate emissions. The high concentration of NO_x measured during the peak hour traffic is a pointer to the fact that vehicle emission is the main contributor to the pollutant gases in Kenyan cities (Patel *et al.*, 2011).

The overall proportion of urban dwellers in Kenya has continued to increase over the years due to migration to cities in search of employment and expectations of better living conditions from 8% in the 1980s to over 34% in 2003 and is expected to reach 50% by 2020 (Ministry of Transport, 2000). In view of these facts it is important to relate outcomes related vehicle emission to air pollution.

4.1.1 The Objectives of the Health Study

The main objective was to evaluate the health hazards associated with vehicle emission related to air pollution. The specific objectives of the study included:

a) To identify the vehicle emission pollutants associated with respiratory morbidity and mortality

b) To determine the prevalence of vehicle emission pollutants related illnesses

c) To determine the mortality rate of vehicle emission pollutants related illnesses

d) To estimate the total related costs of vehicle emission pollutants related to illnesses and deaths

e) To develop a model for differentiating illnesses attributed to vehicle emission pollutants and other sources of air pollution.

4.1.2 Summary of Outputs and Outcomes

The outputs and outcomes of medical report are summarized in the Table 4-1.

Table 4-1: Outputs and Outcomes of the Medical Study

OUTPUTS	OUTCOMES
i. Prevalence of vehicle emission pollutants related illnesses	i. Improved knowledge on effects vehicle emission pollutants related illnesses at individual family and country levels
ii. Mortality rate of vehicle emission pollutants related illnesses	ii. Improved knowledge on effects of vehicle emission pollutants related illnesses at individual family and country levels
iii. Model tool developed	iii. Functional model tool implemented and in use differentiating illnesses attributed to vehicle emission pollutants and other sources of air pollution

4.2 Adopted approach and methodology

Key informants in the respective ministry were interviewed. Desk review of previous literature and the list of all reported cases of air pollutants related illnesses between 2010 and 2012 in the ministry of health database were obtained.

Data Collection Instruments: The tools were interviewer structured questionnaire administered to key stakeholders' representative from Ministry of Health headquarters at AFYA house, Kenyatta National Hospital and WHO.

Data analysis: Both qualitative and quantitative data was manually analyzed and organized into the thematic areas as per the study objectives. The data was however first organized in a simple excel tool that supported in the cleaning of data. Specific data on illnesses related to air pollutants was scanty and data triangulation was carried to validate the information.

Limitations: Interviewing key stakeholders' representative had no major limitations. However, obtaining specific data on illnesses and deaths attributed to vehicle emission pollutants had limitations because this information is not routinely collected. The stakeholders reported that there is limited documentation of illnesses and deaths attributed to vehicle emission pollutants in the Ministry of Health and Kenyatta National Hospital.

4.3 Morbidity and Mortality Associated with Vehicle Emission Pollutants

From the key informants' interviews, vehicle emission pollutants that are associated with morbidity included, Particulate Matter (PM), Nitrogen Oxides (NOx), carbon dioxide. The gaps that were reported to contribute to pollution from the vehicle emission included lack of lawful enforcements that allows inspection of vehicles for emission levels and large number of imported second hand vehicles. Suggestions made to improve the management of the vehicle emission pollutants were; to train health workers at all the levels, public awareness on air pollutants and provision of equipment for evaluating lung functioning at outpatient clinics.

4.4 Prevalence of Vehicle Emission Pollutants Related Illnesses

The respondents were aware of the vehicle emission pollutants related illnesses and the most commonly mentioned were Acute Respiratory Illnesses (ARI), chronic lung diseases and cancers. The findings from the ministry of health and Kenyatta National Hospital revealed that there is no functional model for differentiating illnesses attributed to vehicle pollutants and other sources of air pollution. This is difficult as a result of lack of tools for recording data on vehicle emission related illnesses. However it was mentioned that, there has been an increase in the prevalence rate over the years (Table 4-2). The reasons mentioned for the increased prevalence of these illnesses were:

a) Inadequate legislation
b) Lack of public awareness
c) Inadequate enforcement of the law,
d) Congestion especially in the major cities,
e) Traffic jams
f) Increased number of vehicles on the roads.

Table 4-2: Prevalence of respiratory diseases between 2010 and 2012

705A (outpatient cases <5yrs)			
	2010	**2011**	**2012**
Tuberculosis	36,687	4,211	3,665
Other Diseases of Respiratory System	1,789,042 (86%)	5,140,351 (90%)	5,339,870 (91%)
Pneumonia	253,730	563,171	533,002
Total	**2,079,459**	**5,707,733**	**5,876,537**
705B (outpatient cases >5yrs)			
	2010	**2011**	**2012**
Tuberculosis	18557	44470	41764
Other Diseases of Respiratory System	1838568 **(90.6%)**	6119353 **(90.9 %)**	7112942 **(91.6%)**
Pneumonia	171045	562992	610729
Total	**2028170**	**6726815**	**7765435**

Source: *Ministry of Health*

Table 4-3 captures the emissions of NOx based on the vehicle fleet population and the Vehicle Kilometers Covered (VKM), the estimates show vehicle emissions of NOx amounting to 104 tonnes in 2012. Using the same approach, vehicle emissions for PM stood at 148 tonnes. Motorcycle emissions in the same year recorded 106 tonnes for NOx, while PM levels for motorcycles are insignificant.

Table 4-3: Estimation of vehicle emissions NOx

Estimation of NOx Emissions-Vehicles	
Average No_x emission g/Km	0.03
Calculation of the Average km travelled per day per vehicle (2011 data)	
Total Km travelled (national)	60,303,108,813
Total vehicle (fleet) population in Kenya	1,626,380
Average annual Km travelled (per vehicle)	37,078
Number of days in a year	365
Average daily Km travelled	**101.58**
Total number of newly registered vehicles (2012)	104,332
Daily Fleet Km travelled	10,598,449
Annual fleet km travelled (365)	3,868,434,159
Average NOx emitted in 2012	**104,447,722**
Conversion factor	1,000,000
Tonnes emitted (1/1000000)	104

Source: *Authors computation*

It was reported that health care providers have the capacity to effectively handle the person affected by illnesses associated with vehicle emissions but this depends on the level of the health facility. For instance, it was mentioned that referral hospitals have the capacity whilst the health centers lack the capacity. Gaps identified as barriers for effective health care provision to persons with vehicle emission related illnesses were: lack of training, lack of necessary equipment, inadequate staffing among others. The respondents admitted that there are financial challenges involved in the management of vehicle emission illnesses but there was no data available to ascertain this.

4.5 Estimates of total costs of vehicle emission pollutants, related illnesses and deaths

The KNH patients' data base is being used to estimate the economic loss due to vehicle emission pollutants related illnesses and deaths. The unreported and asymptomatic vehicle emission pollutants related illnesses and deaths cases are assumed to constitute 10% of the total cost per year. The economic losses arise from various factors including; consultation fee, laboratory tests and other diagnostic procedures such as; X- rays/ultrasound, chemotherapeutic or surgical treatment (if applicable), hospitalization and convalescence, life impairment and fatalities. The direct costs include consultation fee, diagnostic tests (X-ray/ultrasound), surgical operation, hospitalization (maximum 5 days), logistical costs (bus fare) and follow up visits costs. Indirect costs include all the opportunities that are lost as a result of the death of a family bread winner and disability due to vehicle emission pollutants related illnesses and deaths.

The non-monetary burden of vehicle emission pollutants related illnesses was estimated using the Disability Adjusted Life Year (DALY). These refer to the sum of years of potential life lost due to premature mortality and the years of productive life lost due to disability. The indirect costs are difficult to quantify in monetary terms as almost all the recorded cases have no information on employment status and/or their main occupation. The lost opportunity costs corresponded to the productive time lost due to an affected person working less efficiently than uninfected person. It was assumed that the same level of lost opportunity applied to the unreported and asymptomatic vehicle emission pollutants related illnesses and deaths cases. The indirect costs or lost opportunities were difficult to quantify in monetary values and were not used to evaluate the economic impact of vehicle emission pollutants related illnesses and deaths in the survey.

Table 4-4 provides the estimated direct costs associated with treating non-communicable respiratory illnesses. In 2012, the total costs stood at approximately KShs. 115 billion. However, it should be noted that the figures are based on the assumption that 50% of the cases treated were attributable to vehicle related emissions. The assumption is driven by the fact that it has been estimated that 90% of urban air pollution in rapidly growing cities in developing countries is attributable to motor vehicle emissions (UNEP, 2010). Generally, there are many sources of air pollution in Nairobi, including open air burning of refuse and biomass, industrial operations and domestic cooking fires. But motor vehicles play a critical role in the problem (Kinney *et al.*, 2011). Based on this knowledge, it follows that considerable amount of non-communicable respiratory illnesses would be attributable to air pollution from vehicle emissions.

Table 4-4: Economic loss due to vehicle emission pollutants related illnesses and deaths in monetary terms for patients treated

YEAR	2012
No. of patients seen with non-infectious respiratory illnesses/year*	6,235,470
Rate -approximate cost of treating a per patient per year **	16,800
ECONOMIC LOSS PER YEAR (KShs)	104,755,887,600
ECONOMIC LOSS PER YEAR (With additional 10% for unreported and asymptomatic cases)	115,231,476,360

Note:

* Assumption: 50% of cases attributed to vehicle emissions PM and No_x =12,470,939

** Based on Kenyatta National Hospital (KNH) Data fees

Data source: *Health Information Management at KNH*

4.6 Estimating Disability Adjusted Life years on account of emissions related illnesses

According to the World Health Organization (WHO), DALYs for a disease or health condition are calculated as the sum of the Years of Life Lost (YLL) due to premature mortality in the population and the Years Lost due to Disability (YLD) for people living with the health condition or its consequences:

The Model applied therefore is:

$$DALY = YLL + YLD \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [4.1]$$

The Years of Life Lost is associated with mortality and it refers to the number of deaths multiplied by the standard life expectancy at the age at which death occurs.

The Model is expressed as:

$$YLL = N \times L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [4.2]$$

Where;

N = Number of deaths

L = Standard life expectancy at age of death in years

The years lost due to disability YLD, is computed by multiplying the number of incident cases in that period by the average duration of the disease and a weight factor that reflects the severity of the disease on a scale from 0 (perfect health) to 1 (dead). The Model is as illustrated in equation 4.3.

$$YLD = I \times DW \times L \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots [4.3]$$

Where;

I = number of incident cases

DW = disability weight

L = average duration of the case until remission or death (years)

The data fact sheet in Table 4-5 was applied to run the formula.

Table 4-5: Data fact sheet for computing DALYS

Number of deaths due to non-communicable respiratory illnesses (N)*	498,837
Standard life expectancy at age of death in years (L)**	32
Number of incident cases (I)	6,235,470
Disability weight (DW)***	0.25
Average duration of the case until remission or death (years) (L^)***	3 days

Note:

* Average mortality rate of 8% is applied for non-communicable respiratory illnesses in Kenya. We assume 50% of respiratory illnesses were attributed to vehicle emissions.

** Average life expectancy at death was assumed to be 50% the life expectancy at birth in Kenya assuming a bulk of patients of respiratory illnesses died between 18-35 years of age. This is necessitated due to lack of specific data on age and sex of patients who died

***Based on medical practitioner opinion from experience

From the above, YLL is computed as

YLL= 498, 837 x 32

YLL = 15,962,784

We compute YLD as follows:

YLD = 6235470 x 0.25 x 3

YLD = 4, 676, 603

Therefore,

DALYs = 15,962,784 + 4,676,603= 20,639,387

4.7 Findings and Discussions

a) More quantitative data and analytical study is required to make distinct conclusions. This may be achieved by carrying out periodic annual systematic monitoring (surveillance) of total suspended particulate (TSP) matter and elemental concentrations.

b) Periodic estimation of economic burden of vehicle emission pollutants related illnesses is important to plan and implement cost-benefit program for the control and prevention strategies. This requires partnerships with interested potential stakeholders within the country / local community for research.

c) Capacity building to improve competencies through on job training to screen, make appropriate diagnosis and analysis of the data.

d) Strengthening of existing infrastructure systems by designing integrated information systems at various levels of the health care system such as a referral tool to provide timely management of air pollutants related illnesses and investment in public transport and urban road infrastructure to reduce road deterioration, numbers of motor vehicles and congestion. Improve stakeholders support to enforce laws and regulations to protect health and ensure safety of vulnerable groups via enforcement of clean air Legislation Acts and regulations directed to reduction in vehicle emissions in Kenya.

4.8 Conclusions

The analysis provides an estimate of the direct and indirect costs of non – communicable illnesses attributable to vehicle emissions. Various assumptions were applied based on expert opinion and experience due to the limitations in data systems. The estimates can be used to build a scenario of the public health costs incurred due to emissions. The findings can motivate increased attention and action to mitigate vehicle emissions.

The prevalence levels of > 90% among those < 5 and > 5 years from this survey concurs with previous study which revealed increased risk of upper respiratory infections in children in the polluted city compared to those in the less polluted cities (Jaakkola *et al.,*1991*).* The high prevalence among those > 5 years supports the findings of Odhiambo *et al.*, 2010 which revealed correlation between fine particulates and vehicle density in Kenya.

The disease burden as measured by DALYs will help in the development of cost-effective strategies to reduce the health burden due to vehicle air pollution. These results may influence implementation of urban transportation and planning policies in relation to air quality and health by comparing subsequent mortality and morbidity rates to determine health impact assessments of various strategies in place. About 20% of Kenya's burden of disease (measured in Disability Adjusted Life Years—the years of life lost due to early death and living with disability) can be attributed to certain risks including: childhood underweight; household air pollution; suboptimal breastfeeding; iron, vitamin A and Zinc deficiency; poor sanitation and inadequate/unsafe water and problems with care facilities especially among the poor. The common problems with provision of care at health facilities reported by the poorest Kenyans includes; long waits, lack of medicines, lack of attention and high cost of services. In recognition of the fact that high cost of services and inadequate access contribute to the problems of health facilities ,the Government of Kenya established the Health Sector Services Fund (HSSF) in 2010 to disburse operational funds directly to health centres and dispensaries, in an effort to improve service delivery as well as accountability.(Kenya economic world bank update 2013).

In the survey the total cost of treating one respiratory illness case was approximately 197 US dollars per year. This figure was based on assumption that the clients' were treated in outpatient department once per year and admitted once per year. This is not affordable by many poor Kenyans. Consequently, improving air quality which has been shown to reduce the burden of respiratory disease would be a cost effective strategy (Hedley *et al.*, 2002). The study of Hedley *et al* (2002) demonstrated that use of low sulphur fuels in Hong Kong was associated with between 2.01% and 3.90% reductions in cardiovascular, respiratory and all-cause death respectively.

There were challenges across the stakeholders in getting the specific illnesses associated with vehicle emission pollutants. The ministry of health may have inadequate human resource capacity/systems/structures for systematic collection, analysis and interpretation of data related to morbidity and mortality associated with vehicle emission pollutants. The inadequate data poses a challenge for integrated planning and management of the vehicle emission pollutants and undertaking accurate total economic valuation.

Despite advances in public health for the last 50 years the ministry of health is largely underfunded. The Kenya's total expenditure on health by 2010 was 5.4 percent of GDP, below the SSA average of 6.5 percent (Kenya economic World Bank update 2013). The emerging and re-emerging diseases infectious have also created competing interest with the Non-communicable disease such as vehicle emission pollutants related illnesses in health service provisions and all effort to develop cost effective and sustainable preventive strategies should be adopted.

5 COST BENEFIT ANALYSIS (CBA)

5.1 Introduction

According to the International Energy Agency (IEA, 2012), the fuel demand and CO_2 emissions are likely to double by 2050 from the base year of 2010. This implies that cost effective measures have to be put in place to improve the fuel efficiency of which nearly 50 per cent is accounted for by the vehicles. It is worth noting that as at 2005, the global average fuel economy was estimated at 8L/100km and there are current efforts to half the level by the year 2050 (GFEI 2013).

Although there are several Nations that have put in place or are currently working towards enhancing the energy efficiency standards in their jurisdictions, there are countries that lack policies to promote fuel efficiency. Notwithstanding, these countries are key markets to commodities that require a lot of energy to operate. It is against this backdrop that the Global Fuel Economy Initiative (GFEI) seeks to assist individual countries to adopt fuel economy policies in relation to the energy security, CO_2 emissions and climate change while at the same time ensuring economic stability (IEA 2012). Importantly, before adopting these set of policies there is need to test the viability and suitability of the proposals based on their estimated cost and benefits to the public.

Cuenot (2013) defines Cost-Benefit Analysis as a set of generally accepted methodological rules that seek to identify, analyze and present economic information to decision-makers as a basis to make choices between options having the potential to address a problem or opportunity. The methodology has widely been used in situations where, if a problem is identified as having a potentially serious public policy concern, then there is need to analyze the problem and determine how significant it is from an economic perspective. Secondly, Cost Benefit Analysis (CBA) is of great importance to comparatively analyze practical options for responding to the problem in terms of options providing the greatest benefits to problem at the lowest cost.

The Cost-Benefit Analysis (CBA) framework was applied in this project as a tool to aid in decision making, by defining and comparing the benefits and costs of the various policy interventions which promote automotive fuel economy. CBA was used to assist in identifying, measuring, and valuing in monetary terms the benefits and costs of identified policy interventions.

5.1.1 Objectives of CBA

In this project, CBA was deployed from the perspectives of: Economic analysis; financial analysis; and social analysis. The main objective for this was to take into account the perspectives of the society (public - welfare). The specific objectives were:

a) To define the policy intervention and instruments used under the CBA framework.
b) To identify and measure the expected costs and benefits from the policy interventions
c) To estimate the indicators of policy instrument feasibility
d) To select the feasible policy instrument using the CBA decision criterion.

5.1.2 Summary of Outcomes

It is intended that the CBA will aid in narrowing the margin for pure judgment in decision making on the proposed interventions for fuel efficiency, vehicle emissions and public health. The primary outputs and utility of the CBA include recommendations on the acceptance or rejection of the policy interventions. Table 5-1 presents the criteria used for accepting or rejecting a policy intervention (Groenendjik and Dopheide, 2003) and (Conway, 2009).

Table 5-1: Criteria for accepting or rejecting a policy intervention

Indicator	Decision	
	Accept	Reject
NPV	NPV>0	NPV<0
IRR	IRR>discount rate (10%)	IRR<discount rate
BCR	BCR>1	BCR<1

It can be seen from the table that a combination of positive Net Present Value (NPV), Benefit Cost Ratio (BCR) and Internal Rate of Return (IRR) that is higher than the selected discount rate is a preferred criterion for selecting a policy intervention.

5.1.3 Scope of the CBA

a) The time horizon for the CBA covered short, medium and long terms taking into account the GFEI framework and the 50 by 50 target.

b) The policy interventions have been categorized into fuel tax interventions and vehicle options.

c) The CBA was limited to the direct costs and benefits of the policy interventions.

5.1.4 Purpose of the study

In view of the current debate on developing mechanisms geared towards enhancing energy efficiency, there has been need to design policies that are effective in reducing the level of average fuel economy, the CO_2 emissions and at the same time enhancing economic sustainability for governments. It is therefore important to undertake a Cost benefit study of some of the proposed fuel economy policy instruments to help policy makers in decision making going forward.

5.2 Operationalization of the CBA

Step 1: Definition of the Policy Intervention / Project

5.2.1 Identification of policy instruments/ options

The first step of the CBA entailed definition and identification of policy instruments that were to be tested through the CBA framework. The policy instruments were identified from the International Energy Agency (IEA) - Fuel Economy Policies Impact tool (FEPit) and were categorized into: regulatory instruments; economic instruments; education/information instruments and other instruments.

In particular, the CBA considered the following policy options:-

a) **Fuel tax options** which essentially deal with the tax and levies on the amount of fuel consumed by the vehicle. It is worth noting that fuel consumption characteristics of the vehicle fleet in a country and determines the average fuel consumption for every kilometer travelled. Therefore imposing a tax or levy on fuel used is expected to have a high policy impact at all levels of the economy. The fuel options include;
   (i) Fuel Tax
   (ii) Fuel tax differentiation (lower tax for diesel or for petrol)
b) **Vehicle Options** this include the following interventions such as labeling requirement for the fleet, CO_2-based Vehicle acquisition and ownership tax, and used vehicle import restrictions that have been applied previously in the country.

The CBA was limited to the direct costs and benefits of the policy interventions. The analysis was conducted separately for independent policy interventions as well as simultaneously for the complete set of interventions. The CBA focused on the differences between the situation with and the situation without the policy intervention. The costs and benefits in the CBA were interpreted as incremental hence justifying the need to analyze the situation of what would have happened without the policy intervention (status quo).

Definition of the time horizon and physical boundary

The time horizon for the CBA was tailored to cover medium and long terms taking into account the GFEI framework and the 50 by 50 target. It also reflects Kenya's long term development blue print, Kenya Vision 2030. The physical boundary was the National context given that the interventions analyzed were treated as National Policies.

Specification of perspective and approach

With and without approach - The CBA focused on the differences between the situation with and the situation without the policy intervention. The costs and benefits in the CBA were interpreted as incremental hence justifying the need to analyze the situation of what would have happened without the policy intervention (status quo).

Economic Analysis - The economic CBA was undertaken to adopt a wider societal perspective in order to determine whether the policy intervention contributes to the economic welfare of the Nation. External effects attributable to the policy interventions were included in the form of public health and environmental parameters.

Social analysis -The CBA also included a social analysis of emission related illnesses. The main objective of the social analysis component in the CBA was to evaluate the health hazards associated with vehicle emission related to air pollution.

Step 2: Identification and measurement of costs and benefits

5.2.2 Identification of policy specific effects (incremental costs and benefits)

The International Energy Agency - Fuel Economy Policies Impact tool (FEPit) was used to determine the policy specific effects in relation to fuel efficiency –liters of fuel per 100 kilometers (L/100km) and vehicle emissions – grams of carbon dioxide emitted per kilometer travelled (gCO_2/km). The use of the IEA-FEPit framework was informed in keeping with the ToR requirement to apply a methodology that creates uniform and standard outputs that are interoperable, comparable and shareable globally. Table 5-2 captures the policy options and scenarios in the tool kit.

Table 5-2: Policy Scenarios for both fuel and vehicle options

Category	Fuel options		Vehicle options			Intervention Level
	Fuel Tax	Fuel Tax differentiation	Acquisition Tax	Ownership Tax	Import Restriction	
1.	Heavy fuel subsidy	All fuels taxed the same way	No vehicle tax, or vehicle tax not depending on fuel economy			None
2.	5% subsidy to 20% tax	Diesel 5-15% cheaper than gasoline	0-5% of average vehicle price between most and least efficient vehicle		> 10 years	Low
3.	20-50% tax on fuel price	Diesel 15-25% cheaper than gasoline	5-15% of average vehicle price between most and least efficient vehicle		5 years - 9 years	Medium
4.	50-100% tax on fuel price	Diesel 25-35% cheaper than gasoline	15-25% of average vehicle price between most and least efficient vehicle		< 5 years	High

Data from the Kenya Vehicle Inventory was used to update the FEPit toolkit to reflect local and current conditions. Each policy instrument was tested for its effect on (L/100KM) and (gCO_2/km). It is important to note that in the Kenyan context, the policy scenario can be described as medium since the import restriction is 8 years and the fuel tax is estimated at 30 per cent of the fuel price.

CBA: Options on fuel and CO2 emission controls

The study identified the following scenarios for analysis and consideration in policy implementation especially within the transport sector. The options are described in Table 5-3.

Table 5-3: Description of scenarios and policy options

Transport Sector Management Options	Scenarios
Option 1: Status Quo	Predominantly based on vehicle technology
	No enhanced enforcement of all regulations
	No inspection routines for all vehicles
	Current state of infrastructure
Option 2: All policies in place	Full regular inspection and enforced compliance to existing standards
	Improved infrastructure, high vehicle and tax options
	Increased population of hybrid vehicles
Option 3: Vehicle Options	Labeling of CO2 emission of vehicles
	Restriction on age of imports high
	CO_2 based acquisition costs
Option 4: Fuel Tax Options	Tax and levies on fuel
	Taxation incentives on acquisition of fuel efficient vehicle

Source: Authors' compilation

Option 1 describes the status quo which is based on the current state of infrastructure, normal way of operations within the industry (where there exists no enhanced enforcement of regulations) such as routine inspection of vehicles. The second option describes the ideal situation where all policies are fully implemented such as the compliance to existing standards and regular inspection. This is in addition to improved infrastructure and vehicle technology. The third option describes the policies that relate to the vehicles such as restriction on age and requirements for labeling of CO_2 emission by vehicles. Lastly, option four describes the implementation of policies that relate to fuel tax levies such as fee-bates on ownership and acquisition of fuel inefficient vehicles and rebates on fuel efficient vehicles.

Table 5-4 summarizes the effects of using with and without approach for three time steps namely: 2012, 2030 and 2050. It gives the projected fuel consumption and carbon emissions under the options of first, the status quo remains, combined fuel tax and vehicle labeling, vehicle labeling options only and implementing fuel tax options only.

Table 5-4: Identification of Direct Policy Effects on Fuel Efficiency and Vehicle Emissions

OPTION 1	**2012**	**2030**	**2050**
If Status quo (gCO_2/Km)	185.35	174.3	174.2
(L/100km)	7.73	7.3	7.2
OPTION 2	**2012**	**2030**	**2050**
All Policies Implemented (gCO_2/km)	185.35	132.3	95.65
(L/100km)	7.73	5.5	3.9
OPTION 3	**2012**	**2030**	**2050**
Vehicle Options (gCO_2/km)	185.35	149.4	122.5
(L/100km)	7.73	5.97	4.7
OPTION 4	**2012**	**2030**	**2050**
Fuel tax Options (gCO_2/Km)	185.35	161.4	143.5
(L/100km)	7.73	5.8	4.4

Data source*: KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory*

In Table 5-4, we observe that if status quo remains, the level of carbon emissions from vehicles is projected to be 174.2gCO_2/Km and the fuel consumption 7.2 L/100km in the year 2050. Also, the results show that if a combination of fuel tax and vehicle labeling options are implemented, the level of carbon emissions and fuel emissions is projected to be 95gCO_2/km and 3.9L/100km respectively. The level of carbon emission and fuel consumption is projected at 122.5gCO_2/km and 4.7 L/100km respectively if vehicle labeling options only are implemented. Lastly, the level of fuel emission and fuel consumption is projected at 143.5gCO_2/km and 4.4 L/100km respectively if fuel tax options are implemented. Further, non-monetized effects are described in a qualitative way and noted in discussion of results.

Step 3: Putting monetary values on costs and benefits

5.2.3 Application of monetization method and estimation of monetary costs and benefits

Using the vehicle inventory data (fleet characteristics) and the Fuel Economy Policy Impact tool (FEPIt), a baseline for the fuel efficiency and CO_2 emissions was developed (Cuenot 2013). The base year was 2012. It is worth noting that the vehicle inventory data indicates that 99 per cent of the new registrations are used imports. At the same time, the share petrol driven vehicles increased to 88.98 per cent in 2012 from 84.38 per cent in 2010. Hybrid vehicles constitute less than 0.05 per cent of total registrations in both 2010 and 2012. The important fleet characteristics that were utilized in the FEPit toolkit were; fuel type split used by vehicles; the vehicle class that is based on the engine size; the average age and share of used vehicles in the inventory.

Fuel efficiency costs and benefits

Table 5-5 indicates the estimates of costs based on the total fuel consumption and the petrol price. The estimates are based on an average pump price of KShs 113.75 and an average fuel consumption of 7.61 L/100km. Importantly, is the estimated average daily kilometer travel of 101 km based on data from the KIPPRA transport data compendium. The formula below was applied in computing the estimated financial costs based on fuel consumption vehicle kilometers travelled and prevailing pump prices, with variables in Table 5-5.

Estimated Financial Cost = annual fleet km travelled * amount in KShs per km

Where;

Annual fleet km = average daily Km*number of vehicles using petrol *365

Amount in KShs per km = Average fuel economy * average fuel price/ 100

NB: The formula is applied with adjustments when computing for diesel vehicles and motorcycles.

Table 5-5: Estimation of costs in 2012 based on total fuel consumption and pump price (petrol)

Estimation of Financial costs 2012 based on total fuel consumption and pump price - Petrol	
Average fuel economy (L/100km)	7.61
Average fuel price (petrol)	113.75
Total amount (KShs/100km)	865.64
Conversion factor	100.00
Amount in KShs per km	**8.66**
Calculation of the Average km travelled per day per vehicle (2011 data)	
Average daily km travelled	**101.5838837**
Number of vehicles using petrol (inventory 2012)	92,830.00
Daily Fleet km travelled	9,430,031.92
Annual fleet km travelled (365)	3,441,961,651.71
Estimated Financial Cost	**29,794,910,792**

Data source: *KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory*

Table 5-5 captures the parameters and approach applied in monetizing the baseline scenario and the policy specific effects identified above. It reveals that at the current fuel economy level (7.61 L/100km), it costs the economy approximately KShs 29 billion per year in fuel consumption based on prevailing pump prices.

Table 5-6 indicates the estimates of costs based on the total fuel consumption and the diesel price. The estimates are based on an average pump price of KShs 105.31 and an average fuel consumption of 8.10 L/100km.

Table 5-6: Estimation of Financial costs 2012 based on total fuel consumption and pump price – (diesel)

Estimation of Financial costs 2012 based on total fuel consumption and pump price -diesel	
Average fuel economy (L/100km)	8.10
Average fuel price (diesel)	105.31
Total amount (KShs/100km)	853.03
Conversion factor	100.00
Amount in KShs per km	**8.53**
Calculation of the Average km travelled per day per vehicle (2011 data)	
Total km travelled (national)	60,303,108,813.00
Total vehicle (fleet) population in Kenya	1,626,380
Average annual km travelled (per vehicle)	37,078.12
Number of days in a year	365
Average daily km travelled	**101.5838837**
Total number of newly registered vehicles (2012)	104,332.00
Number of vehicles using petrol	11,476.52
% of vehicles using diesel	11.00%
Daily Fleet km travelled	1,165,829.47
Annual fleet km travelled (365)	425,527,757.57
Estimated Financial Cost	**3,629,867,515.61**

***Data source**: KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory*

The estimates for diesel were computed using the same approach as was done for petrol and yielded a cost of KShs. 3.6 billion. The number of newly registered vehicles using diesel constitute 11 per cent of the total vehicle registered in 2012. Table 5-7 indicates the estimated financial cost of fuel consumption of motor cycles based on an average fuel economy of 2.60L/100km and the average daily travel distance estimated at 200km.

Table 5-7: Estimation of Financial costs 2012 based on total fuel consumption and pump price – (motor cycles)

Average fuel economy (L/100km)	2.60
Average fuel price (petrol)	113.75
Total amount (KShs/100km)	295.75
Conversion factor	100.00
Amount in KShs per km	**2.96**
Number of days in a year	365
Average daily km travelled	**200**
Total number of newly registered motor cycles (2012)	97,052.00
Number of motor cycles using petrol	97,052.00
% of motor cycles using petrol	100.00%
Daily Fleet km travelled	19,410,400.00
Annual fleet km travelled (365)	7,084,796,000.00

Estimated Financial Cost	**20,953,284,170.00**

Data source: *KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory*

The results in Table 5-7 estimate that expenditure on motorcycle fuel consumption at KShs 20 billion. In summary, the overall total expenditure is estimated at **KShs. 52 billion annually**, from this the government revenue from fuel sales at pump prices is estimated at 15.8 billion, assuming a 30% share of government taxes and levies. For the purposes of this CBA, the government revenue that will be foregone due to implementation of fuel economy policies will be treated as a cost, while the reduction in annual expenditure on fuel will be treated as a benefit.

Vehicle emissions costs and benefits

Estimation of vehicle CO_2 emissions based on an average of 185.35gCO_2/km in 2012 reveals that a total of 717 thousand tonnes of CO_2 was emitted, as shown in Table 5-7. In order to monetize the emissions for the CBA, an average price of verified Carbon Standard is estimated at USD 1 per ton of CO_2 was applied based on the Carbon Trade Exchange (CTE) and the Intercontinental Carbon Exchange (ICE). This exchange serves the United States, Europe, Australia and China.

Table 5-8: Estimation of benefit of foregone CO_2 Emissions - Vehicles

Estimation of Financial benefit of foregone CO2 Emissions	
Average CO_2 Carbon credit per ton (USD)*	**1.00**
Exchange rate (1US$ to Ksh)	85.00
Average CO_2 emission gCO_2/km (in 2012)	185.35
Calculation of the Average km travelled per day per vehicle (2011 data)	
Total km travelled (national)	60,303,108,813.00
Total vehicle (fleet) population in Kenya	1,626,380
Average annual km travelled (per vehicle)	37,078.12
Number of days in a year	365
Average daily km travelled	**101.5838837**
Total number of newly registered vehicles (2012)	104,332.00
Daily Fleet km travelled	10,598,449.75
Annual fleet km travelled (365)	3,868,434,159.72
Average gCO_2 emitted in 2012	**71,701,427,150.325**
Conversion factor	1,000,000.00
Tonnes emitted (1/1000,000)	717,014.27
Average Carbon credit per ton	850.00
Estimated Financial Benefit	**60,946,213.078**

Data source: *KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory; World Bank*

Based on this criterion and working with estimated annual fleet kilometers travelled, the emissions in 2012 were valued at KShs 60.9 Million. The policy interventions were analyzed to establish their effect on reducing emissions. The benefits to the economy lie in establishing the amount of CO_2 emissions avoided and the value accrued upon registering and selling the carbon credits.

Table 5-9 shows the estimation of benefit of foregone CO_2 emission from motorcycles based on carbon emission estimates of 44.50gCO_2/km and average daily kilometer travelled estimated at 200 km.

Table 5-9: Estimation of benefit of foregone CO_2 Emissions – Motor cycles

Estimation of Financial benefit of foregone CO2 Emissions (Motor Cycles)	
Average CO_2 Carbon credit per tonne (USD)*	1.00
Exchange rate (1US$ to KShs)	85.00
Average CO_2 emission gCO_2/km (in 2012)	44.50
Calculation of the Average km travelled per day per vehicle (2011 data)	
Number of days in a year	365.00
Average daily km travelled	200.00
Total number of newly registered vehicles (2012)	92,052.00
Number of vehicles using petrol	92,052.00
% of vehicles using petrol	100.00%
Daily Fleet km travelled	18,410,400.00
Annual fleet km travelled (365)	6,719,796,000.00
Average gCO_2 emitted in 2012	299,030,922,000.00
Conversion factor	1,000,000.00
Tonnes emitted (1/1000,000)	299,030.92
Average Carbon credit per tonne	850.00
Estimated Financial Benefit	**254,176,283.70**

Data source: *KIPPRA transport data compendium; Consultants Estimates from Vehicle Inventory; World Bank*

Costs associated with vehicle emissions were drawn from the medical report of this project. The costs are associated with direct costs of treating patients of no-communicable respiratory illnesses. As per the medical report, the costs are derived from typical fees and charges at Kenyatta National Hospital. Based on the methodology and assumptions of the medical report, approximately KShs 115 billion was spent on treating patients with respiratory illnesses assumed to emanate from exposure to vehicle emissions. The benefits to accrue from the policy interventions are treated as the savings on treatment costs for respiratory illnesses.

Selection of appropriate discount rate and Discounting of costs to present value

In order to estimate the economic value of the policy interventions in 2050, the CBA made use of a discounting rate of 10% based on best practice references. The interpretation of the consultant was that future costs and benefits weigh less in the decision making framework than those occurring nearer the present time. This perception was guided by concern for issues such as inflation, risk, consumption preferences and alternative investment opportunities. The model 5.1 captures the application of the discount rate (Groenendjik and Dopheide, 2003).

$$Discount\ Rate = \frac{1}{(1+i)^t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [5.1]$$

Where;

i=discount rate in decimals (0.1 for rate of 10%),

t = the future year and Present Value (PV) is equal to Future Value (TV) multiplied by Discount Factor.

Step 4: Calculation of indicators of feasibility

5.2.4 CBA Indicators

In undertaking the CBA the following indicators were derived: Net present Value (NPV); Internal Rate of Return (IRR); Benefit-Cost Ratio (BCR) and Net benefit-investment ratio (N/K ratio). The mathematical formulations are captured in model 5-2 (Groenendjik and Dopheide, 2003).

$$Net\ Present\ Value = \sum_{t=1}^{T} \frac{(B_t - C_t)}{(1+r)^t} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots [5.2]$$

Where;

B_t is the periodic benefit,

C_t is the periodic cost, and

Σ is the summation sign.

Internal Rate of Return (IRR): The discount rate of Return-i is such that

$$\sum_{t=1}^{T} \frac{(B_t - C_t)}{(1+r)^t} = 0 \qquad \text{.....................................} [5.3]$$

The Net Benefit Investment Ratio (N/K):

$$= \frac{\sum_{t=1}^{T} \frac{N_t}{(1+r)^t}}{\sum_{t=1}^{T} \frac{K_t}{(1+r)^t}} \qquad \text{.....................................} [5.4]$$

Where;

N_t is the incremental net benefit in each year after the stream has turned positive,

K_t is the incremental net benefit in initial years when the stream is negative,

n is the number of years (hence t=1,2,…,n) and

r is the discount rate.

Results of feasibility analysis 2050

In this study, as previously mentioned and utilizing the GFEI toolkit, option 1 assumes a status quo where no policy is implemented but there are improvements in the vehicle making industry that lead to reduced CO_2 emissions and fuel consumption per kilometer travelled. As shown in Table 5-10, option 1 gives an IRR of 17%.

However, Option 2 considered the scenario when combinations of the various policies are implemented both for fuel tax options and vehicle options. These resulted in the highest IRR of 18%. Option 3 includes implementing vehicle policies only that yield at least some policy impact while; the results give an IRR of 17%. While option 4 assumes that only the fuel tax options are implemented with no vehicle options. These include high fuel tax and differentiation that yields at least some policy impact when applied; the result is IRR 17%. Testing for the Cost Benefit Analysis various policy options that have been presented under the GFEI Framework yields the following Net Present Value and the IRR (Table 5-10).

Table 5-10: Estimated NPV and IRR results from the Benefit Analysis in 2050

Policy Options	NPV (Billion KShs)	IRR (%)	BCR	PV Savings (Billion KShs)
Option 1	51.7	17	0.9753	1.4
Option 2	59.4	18	4.9794	7.2
Option 3	54.5	17	3.5964	5.3
Option 4	54.7	17	3.9331	5.3

NB: *Discount rate is estimated at 10%, based on Central Bank discounting rates and best practice.*

From Table 5-10, it can be seen that policy Option 1, yields a Net Present Value (NPV) of KShs 51.7 billion with a Benefit Cost Ratio (BCR), of 0.98 and present value of savings estimated at KShs 1.4 billion. Implementation of Option 2 yields a Net Present Value (NPV) of KShs 59.4 billion with a Benefit Cost Ratio (BCR), 4.98 and an estimated present value of savings worth KShs 7.2 billion. This Option would be considered as the most ideal for policy implementation since it yields the highest potential savings from the mix of policies. Option 3 and Option 4 would be ideal if implementation encompasses both sets of fuel and vehicle labelling options.

In summary, the study establishes that implementation of Option 2 has the potential to yield the highest savings thus the most ideal policy scenario to pursue. On the other hand, Option 1 which is the status quo indicates that failure to take any policy action would lead to costs exceeding the benefits by the year 2050. Armed with the results, the study would recommend a phased adoption and implementation of a policy mix that combines elements of both Option 3 and Option 4 with the goal of having all policies relating to fuel economy and CO_2 emissions put in place.

5.3 Findings and Discussions

a) A strategic mix of vehicle policy options and fuel tax options should be implemented as demonstrated in the CBA analysis. The implementation should be done simultaneously to yield affirmative impacts. However, based on prevailing socio-economic conditions, fuel tax options can be relaxed to moderate levels taking into account the cost of living and of doing business in the economy.

b) Vehicle policy options such as a high CO_2 based vehicle ownership tax are seen to have a very high policy impact and are proposed. Vehicle labeling options and CO_2 based vehicle acquisition taxes are also recommended. The analysis reveals that high used imports restrictions yield very small policy impacts and are therefore not proposed. It should be noted that vehicle options can be implemented individually. However, fuel tax options should not be implemented as stand-alone interventions.

c) Before implementation of any policy instruments, thorough consultation with a broad spectrum of stakeholders should be undertaken. This should be done to fully capture financial and economic costs/benefits from a varied array of perspectives. The consultation process is anticipated to improve the CBA analysis by enriching the scope of estimated policy effects.

d) Further analysis of the policy interventions adopting the Multi-Criteria Evaluation (MCE) methodology is recommended. It is anticipated that the use of alternative approaches will enrich the decision making process and identify qualitative effects that cannot be monetized rationally.

e) Taxes: In the medium term, the state to establish mechanisms to consider the following, fuel tax options / tax rebate systems in relation to CO_2 emissions and fuel efficiency levels. At the same time, reduce per capita annual kilometers travelled through travel demand management strategies in the short term.

5.4 Conclusion on CBA analysis

The CBA analysis was undertaken taking into account three broad categories of interest, namely: Fuel efficiency costs and benefits based on pump prices; Environmental costs and benefits based on CO_2; and public health costs based on the direct medical costs of treating respiratory illnesses. The economic perspective was applied with focus on public interest. Based on the rejection criteria, option 2 gives the best results for implementation. The option considered the scenario when combinations of the various policies are implemented both for fuel tax options and vehicle options. The results yield a greater NPV and IRR compared to the other options and is also more resilient to declines in expected benefits.

In conclusion, it is evident that adopting a policy mix is essential in obtaining highest savings to the society as depicted by the present values. However, beyond looking at the NPV and IRR that, there are other components of benefits to the society such as public health and reduced air pollution issues that need to be considered. These may not be accurately captured in monetary terms but their value can be alluded to in qualitative /scenario based means. The aspect of Disability Adjusted Life Years (DALY) as per the medical report component and global warming can be grouped into this category of effects.

6 STUDY RECOMMENDATIONS

The following specific recommendations were made at the conclusion of the study:

1. **Vehicle Inspection**

The Motor Vehicle Inspection Unit to develop capacity to;

- Conduct regular inspection inclusive of monitoring of emissions for all vehicles.
- Increase capacity of the unit or license credible garages to provide the inspection services to all vehicles and motorcycles.

2. **Taxes**

The state to establish mechanisms that address;

- Fuel tax options / tax rebate systems in relation to CO_2 emissions and fuel efficiency levels.
- Reduce per capita annual kilometers travelled through travel demand management strategies.

3. **Infrastructure and transport planning**

The state to establish a framework for;

- Provision of mass transit (Bus/Train) to enhance a shift from private car dominance.

4. **Health surveillance**

The state to establish a framework to;

- Continuously determine total suspended particulate (TSP) matter and elemental concentrations.
- Conduct periodic estimation of economic burden of vehicle emission related illnesses to plan and implement control and prevention policies and programs.

5. **Vehicle and fuel Standards**

The state to establish a framework to;

- Phase out motorcycles with two stroke engines on account of high pollution and fuel consumption.
- Implement all existing relevant standards.

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8 APPENDIX

A. Definitions

A-1 Test Cycles

How is the fuel consumption test conducted[8]?

There are two parts of a test cycle: an urban and an extra-urban cycle. The cars tested have to be run-in and must have been driven for at least 1,800 miles (3,000 kilometers) before testing.

- **Urban Cycle**
  The urban test cycle is carried out in a laboratory at an ambient temperature of 20^{o}C to 30^{o}C on a rolling road from a cold start, i.e. the engine has not run for several hours. The cycle consists of a series of accelerations, steady speeds, decelerating and idling. Maximum speed is 31mph (50km/h), average speed 12mph (19km/h) and the distance covered is 2.5 miles (4km).

- **Extra-Urban Cycle**
  This cycle is conducted immediately following the urban cycle and consists of roughly half steady-speed driving and the remainder accelerations, decelerations, and some idling. Maximum speed is 75mph (120km/h), average speed is 39mph (63 km/h) and the distance covered is 4.3miles (7km).

- **Combined Fuel Consumption Figure**
  The combined figure presented is for the urban and extra-urban cycle together. It is therefore an average of the two parts of the test, weighted by the distances covered in each part.

A-2 LDV

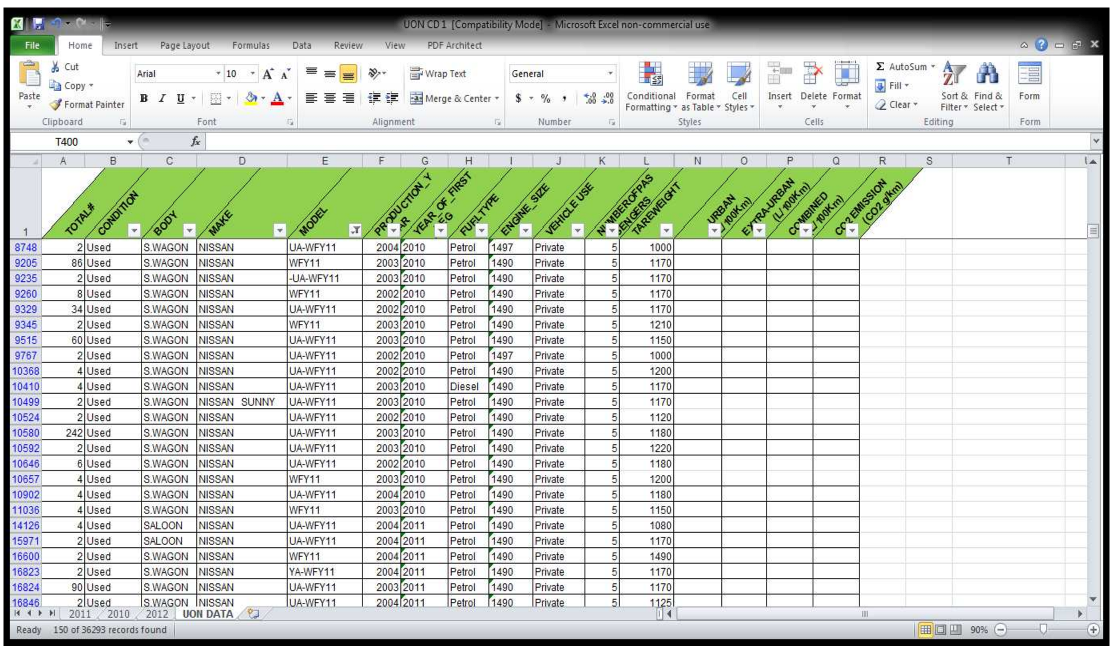
Light Duty Vehicles (LDVs) were defined as the group of vehicles with a gross weight of less than 3500 kg.

[8]http://www.dft.gov.uk/vca/fcb/faqs-fuel-consumptio.asp

A-3 Units of measurement for fuel economy standards

Automobile fuel economy standards can take many forms, including numeric standards based on vehicle fuel consumption (such as liters of gasoline per hundred kilometers of travel [L/100-km]) or fuel economy (such as kilometers per liter [km/L]) or as miles per gallon [mpg]). Automobile GREEN HOUSE GAS emission standards are expressed as grams per kilometer [g/km] or grams per mile [gpm].

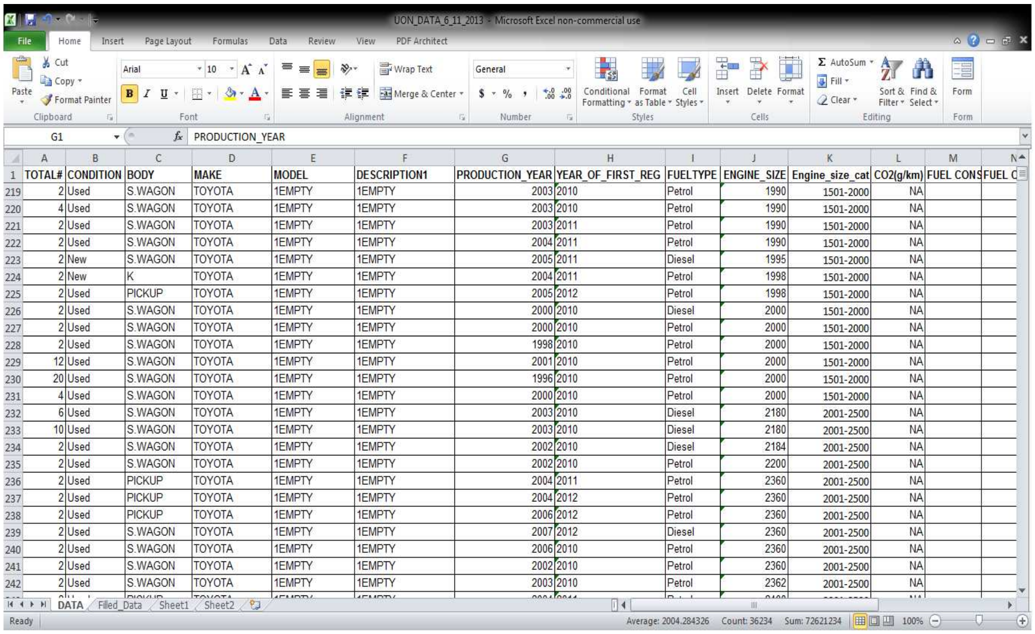
B. Sample page of raw data as availed from KRA



1	TOTAL#	CONDITION	BODY	MAKE	MODEL	PRODUCTION_YEAR	YEAR_OF_FIRST_REG	FUELTYPE	ENGINE_SIZE	VEHICLE USE	NUMBEROFPASSENGERS	TAREWEIGHT	URBAN (L/100Km)	EXTRA-URBAN (L/100Km)	COMBINED (L/100Km)	CO2 EMISSION (CO2 g/km)
8748	2	Used	S.WAGON	NISSAN	UA-WFY11	2004	2010	Petrol	1497	Private	5	1000				
9205	86	Used	S.WAGON	NISSAN	WFY11	2003	2010	Petrol	1490	Private	5	1170				
9235	2	Used	S.WAGON	NISSAN	-UA-WFY11	2003	2010	Petrol	1490	Private	5	1170				
9260	8	Used	S.WAGON	NISSAN	WFY11	2002	2010	Petrol	1490	Private	5	1170				
9329	34	Used	S.WAGON	NISSAN	UA-WFY11	2002	2010	Petrol	1490	Private	5	1170				
9345	2	Used	S.WAGON	NISSAN	WFY11	2003	2010	Petrol	1490	Private	5	1210				
9515	60	Used	S.WAGON	NISSAN	UA-WFY11	2003	2010	Petrol	1490	Private	5	1150				
9767	2	Used	S.WAGON	NISSAN	UA-WFY11	2002	2010	Petrol	1497	Private	5	1000				
10368	4	Used	S.WAGON	NISSAN	UA-WFY11	2002	2010	Petrol	1490	Private	5	1200				
10410	4	Used	S.WAGON	NISSAN	UA-WFY11	2003	2010	Diesel	1490	Private	5	1170				
10499	2	Used	S.WAGON	NISSAN SUNNY	UA-WFY11	2003	2010	Petrol	1490	Private	5	1170				
10524	2	Used	S.WAGON	NISSAN	UA-WFY11	2002	2010	Petrol	1490	Private	5	1120				
10580	242	Used	S.WAGON	NISSAN	UA-WFY11	2003	2010	Petrol	1490	Private	5	1180				
10592	2	Used	S.WAGON	NISSAN	UA-WFY11	2003	2010	Petrol	1490	Private	5	1220				
10646	6	Used	S.WAGON	NISSAN	UA-WFY11	2002	2010	Petrol	1490	Private	5	1180				
10657	4	Used	S.WAGON	NISSAN	WFY11	2003	2010	Petrol	1490	Private	5	1200				
10902	4	Used	S.WAGON	NISSAN	UA-WFY11	2004	2010	Petrol	1490	Private	5	1180				
11036	4	Used	S.WAGON	NISSAN	WFY11	2003	2010	Petrol	1490	Private	5	1150				
14126	4	Used	SALOON	NISSAN	UA-WFY11	2004	2011	Petrol	1490	Private	5	1080				
15971	2	Used	SALOON	NISSAN	UA-WFY11	2004	2011	Petrol	1490	Private	5	1170				
16600	2	Used	S.WAGON	NISSAN	WFY11	2004	2011	Petrol	1490	Private	5	1490				
16823	2	Used	S.WAGON	NISSAN	YA-WFY11	2004	2011	Petrol	1490	Private	5	1170				
16824	90	Used	S.WAGON	NISSAN	UA-WFY11	2003	2011	Petrol	1490	Private	5	1170				
16846	2	Used	S.WAGON	NISSAN	UA-WFY11	2004	2011	Petrol	1490	Private	5	1125				

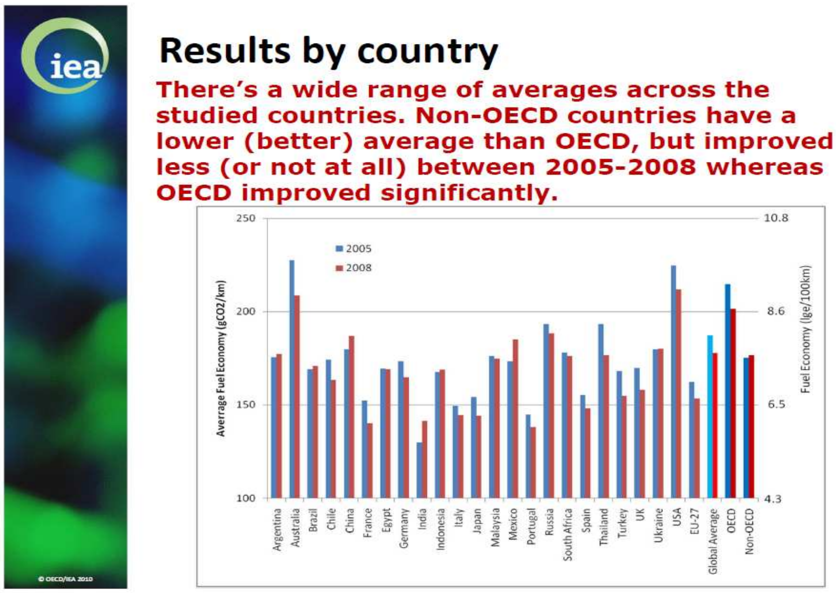
C. Sample page of unclassified entries in the raw data

Several vehicles were missing description and models. These are shown labeled as empty in description column.



	TOTAL#	CONDITION	BODY	MAKE	MODEL	DESCRIPTION1	PRODUCTION_YEAR	YEAR_OF_FIRST_REG	FUELTYPE	ENGINE_SIZE	Engine_size_cat	CO2(g/km)	FUEL CONS	FUEL C
219	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2003	2010	Petrol	1990	1501-2000	NA		
220	4	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2003	2010	Petrol	1990	1501-2000	NA		
221	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2003	2011	Petrol	1990	1501-2000	NA		
222	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2004	2011	Petrol	1990	1501-2000	NA		
223	2	New	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2005	2011	Diesel	1995	1501-2000	NA		
224	2	New	K	TOYOTA	1EMPTY	1EMPTY	2004	2011	Petrol	1998	1501-2000	NA		
225	2	Used	PICKUP	TOYOTA	1EMPTY	1EMPTY	2005	2012	Petrol	1998	1501-2000	NA		
226	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2000	2010	Diesel	2000	1501-2000	NA		
227	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2000	2010	Petrol	2000	1501-2000	NA		
228	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	1998	2010	Petrol	2000	1501-2000	NA		
229	12	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2001	2010	Petrol	2000	1501-2000	NA		
230	20	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	1996	2010	Petrol	2000	1501-2000	NA		
231	4	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2000	2010	Petrol	2000	1501-2000	NA		
232	6	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2003	2010	Diesel	2180	2001-2500	NA		
233	10	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2003	2010	Diesel	2180	2001-2500	NA		
234	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2002	2010	Diesel	2184	2001-2500	NA		
235	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2002	2010	Petrol	2200	2001-2500	NA		
236	2	Used	PICKUP	TOYOTA	1EMPTY	1EMPTY	2004	2011	Petrol	2360	2001-2500	NA		
237	2	Used	PICKUP	TOYOTA	1EMPTY	1EMPTY	2004	2012	Petrol	2360	2001-2500	NA		
238	2	Used	PICKUP	TOYOTA	1EMPTY	1EMPTY	2006	2012	Petrol	2360	2001-2500	NA		
239	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2007	2012	Diesel	2360	2001-2500	NA		
240	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2006	2010	Petrol	2360	2001-2500	NA		
241	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2002	2010	Petrol	2360	2001-2500	NA		
242	2	Used	S.WAGON	TOYOTA	1EMPTY	1EMPTY	2003	2010	Petrol	2362	2001-2500	NA		

D. IEA study on OECD and Non-OECD countries, fuel consumption and CO_2 emission Standards



E. UNEP Datasets for Sample African Pilot studies

Global	2005	2008	2011
Average (l/100km)	8.07	7.67	7.2
OECD Average	8.1	7.6	7.0
Non-OECD Average	7.5	7.6	7.5

Ethiopia	2005	2008	2010
Average (l/100km)	8.4	8.4	7.9
Diesel	9.3	9.4	9.0
Petrol	7.8	7.4	6.9

Kenya	2005	2008
Average (l/100km)	7.69	7.6
Diesel	8.67	9.09
Petrol	7.52	7.2

F. Petrol Powered Motor Vehicle Emission Standards

VehicleClassandModelYear	*Maximum Emission Concentration HP(ppm)*	*CO(percentage)*
Class I:		
Gross vehicle weight of 6000 pounds or less		
1975-1977	500	5.0
1978-1979	400	4.0
1980	300	3.0
1981 +	220	1.2
Class II:		
Grossvehicleweightof6001poundsto10,000 Pounds		
1975-1977	750	6.5
1978-1979	600	5.5
1980	400	4.5
1981-1984	300	3.0
1985 +	200	1.2

G. Diesel Powered Motor Vehicle Emission Standards

Standards and Procedures for Inspection of Diesel Fueled Vehicles-Pass/Fail Criteria

1. Dynamometer Conditions

a) A diesel-powered vehicle with a net weight greater than or equal to 6001 pounds and less than or equal to 10,000 pounds shall be tested on a loaded dynamometer by applying a single load of 30Hp (±2Hp) while being operated at adrivewheelspeedof50mph(±2mph).

b) Adiesel-poweredvehiclewithanetweightof6000poundsorlessshallbe tested on a loaded dynamometer by applying a single load of 9Hp (±2Hp) while being operated at a drive wheel speed of 30mph (±2mph).

2. Opacity Standard

No diesel-powered vehicle shall emit visible emissions in excess of 20% Opacity for 5consecutivesecondsormorewhenundertheapplicableloading.

a) All diesel-powered motor vehicles shall be inspected with an opacity meter that meets the requirements of the Authority.

b) Separate measurements shall be made on each exhaust outlet on diesel-powered motor vehicles equipped with multiple exhaust outlets. For vehicles equipped with more than one exhaust pipe, the reading taken from the outlet giving the highest opacity reading shall be used for comparison with the standard. Exhaust tail pipes on diesel-powered motor vehicles shall allow for safe attachment of

   i. The opacity meter sensor unit. Dual or multiple exhaust motor vehicles will be
   ii. Tested by sampling all exhaust tail pipes simultaneously or individually.

c) Any diesel-powered motor vehicle not meeting the opacity standard shall fail the inspection.

3. Idle Mode Test

When it is necessary to omit the loaded mode test, as specified below, an opacity measurement shall be made while the vehicle is operating at idle under no load.

a) If the opacity measured during the idle mode test is greater than 5%, the vehicle shall fail the inspection.

b) The loaded mode test shall be omitted on any motor vehicle if-

   i. The motor vehicle is in any condition that precludes loaded mode testing for reasons of health or safety, or both, or personnel, facility, equipment or vehicle.

   ii. The motor vehicle is unable to be tested because of the vehicle's inability to attain the speeds specified on the dynamometer.

   iii. The motor vehicle is equipped with a constant four-wheel drive.

c) Re-inspection stations shall not be allowed to perform the idle mode test for diesel-fueled vehicles.

4. Inspection Rejection.

The emissions inspector may refuse to perform the opacity test required by these regulations for any motor vehicle if the motor vehicle has an obvious exhaust system leak or other condition that could affect the validity of the opacity reading, as determined by the emissions inspector.

H. Estimated costs of vehicle emission pollutants related illnesses seen at KNH

S/No.	ITEM	Average approx. cost/year (KShs)	Average approx. cost/year (USD)
1	Outpatient charges including drugs/patient	600	7
2	Laboratory costs; Baseline investigations/ patient	1,700	20
	Logistical costs (e.g. bus fare/taxi etc.)	500	6
3	X -ray	700	8
	Ultra Sound screening	1800	21
	CT scan	7000	82
4	Hospital fee(Bed charges (…800…../day) for 5 days(hospitalization in severe cases)plus drugs and procedures	4,000	47
5	Follow up visits after admission/patient	500	6
Total		**16,800**	**197**

NB: The figures above are based on assumption that the clients are treated in outpatient department once per year and admitted once per

I. Data sheets respiratory diseases 2010-2012

Inpatient	2010	2011	2012
Respiratory tuberculosis/whooping cough	19	1,951	1,271
Neoplasm; Ca larynx, trachea, bronchus and lungs	7	112	31
Other Diseases of respiratory system	186	15,364	18,127
Total	****212**	**17,427**	**19,429**

** Some data for 2010 was missing

705A (outpatient <5yrs)	2010	2011	2012
Tuberculosis	36,687	4,211	3,665
Other Diseases. of Respiratory System	1,789,042	5,140,351	5,339,870
Pneumonia	253,730	563,171	533,002
Total	**2,079,459**	**5,707,733**	**5,876,537**

705B (outpatient >5yrs)	2010	2011	2012
Tuberculosis	18,557	44,470	41,764
Other Diseases of Respiratory System	18,38,568	6,119,353	7,112,942
Pneumonia	171,045	562,992	610,729
Total	**2,028,70**	**6,726,815**	**7,765,435**

Source: *Ministry of Health*

J. Questionnaire/Key Informant Guide

Evaluation of the Health Hazards Associated With Vehicle Emission Related Air Pollution in Kenya

Respondent Information Sheet

Please read to the respondent.

Globally, transport is an important part of modern life and continues to grow. However, certain diseases are related to the air pollution caused by road transport. In Kenya identification of persons with health diseases or related events associated with vehicle emission related air pollution remains a big challenge. Research evidence justifies a range of action to protect health from the harmful effects of transport-related pollutants.

The main objective of this assessment is to evaluate the health hazards associated with vehicle emission related air pollution in Nairobi, Mombasa, Nakuru, Kisumu and Eldoret cities in Kenya. The methods to be used include data collection from relevant stakeholders to identify health effects (morbidity and mortality rates) associated with vehicle emission related air pollution.

We will ask you questions in relation to this main objective. We will use this information in a completely anonymous way, to help improve aspects of your service in serving the clients.

The questions will take about 30 minutes to complete. All information that you provide us will remain strictly private and confidential. We will not write your name anywhere and it will not be linked with your private and professional records. We will not discuss your individual answers with the consultants.

Whether you decide to take part in this survey is voluntary – this means that you do not have to answer these questions. Whether you take part or not will not affect any future association with the consultant. Additionally, you may decline to answer any question or withdraw from the interview without giving a reason.

If you have questions about ***needs assessment***, please contact Dr. Lucy N. Muhia on 0722 789 097 any time.

I certify that I have read to the facility/organization respondent information sheet and have explained this needs assessment to the participant, and that s/he understands the nature and the purpose of the assessment and consent to the participation in the study. S/he has been given opportunity to ask questions which have been answered satisfactorily.

Please tick one box: **The respondent declines to be interviewed**

The respondent agrees to be interviewed

Name of interviewer: ___________________________ **Position:** ____________________

Signature: ___________________________ **Date:** ____________________

SECTION 1: INTERVIEW SITE AND INFORMATION		
I1 QNUM	Unique questionnaire number	_ / _ _ / _ _ _ _ [facility level] [facility code] [respondent number]
I2 NAME	Cadre of the Interviewee	
I3 FACTYP E	Work organization in which the interviewee is based	
I4 DATE	Today's date	_ _ / _ _ / _ _ _ _ (dd / mm / yyyy)

SECTION 2: KNOWLEDGE ON POLLUTION FROM VEHICLE EMISSIONS		
1.	Do you think the Kenyan population is adequately trained on pollution from the vehicle emissions?	Yes……………………………………………..1 No………………………………………………2
2.	What are the gaps in our institutions that have allowed continued pollution from vehicle emissions? ***(Write in the box provided on the right)***	
3.	Are you aware on the documented knowledge levels of illnesses related to emissions from the vehicles**?** If yes, what are the knowledge levels? ***(Probe for the source and reference of this information)***	

4.	According to the vehicle emissions pollutants associated with morbidity and mortality (2010-2012), can you describe what these pollutants are?	i. ……………………………………… ii. ……………………………………… iii. ……………………………………… iv. ……………………………………… v. ……………………………………… vi. ………………………………………

5.	In your opinion, what do you think has led to the increased prevalence of vehicle emissions related illness	i. ……………………………………… ii. ………………………………………… iii. ………………………………………… iv. ………………………………………… v. ………………………………………… vi. …………………………………………
6.	Is there a functional model for differentiating illnesses attributed to vehicle emission pollutants and other sources of air pollution?	Yes……………………………..…..1 No…………………………………2
7.	At what level is this model made available? Is the model made available at the national level, county level etc? *(Probe for availability at the private and public institutions)*	
8.	Do you think the health care providers have the capacity to effectively handle the persons affected by the illnesses as a result of vehicle emissions pollutants	Yes……………………………………..1 No……………………………………….2

9.	What are the existing gaps among the health care providers that are a barrier to health care providers in effectively handling vehicle emissions related illnesses?	i. ……………………………………… ii. ……………………………………… iii. ……………………………………… iv. ……………………………………… v. ………………………………………
10.	Are there financial challenges associated with the management and care of the vehicle emission pollutants	

	related illnesses?	
11.	Are there funds set aside for supporting the vehicle emission pollutants related illnesses?	Yes…………………………………...1 No……………………………………2
12.	Do you have any other suggestions on how GOK can help you improve in the management of vehicle emission pollutants related illnesses in Kenya? ***(Write in the box provided on the right)***	
13.	Kindly provide us with the statistics of documented vehicle emission pollutants related illnesses(morbidity) and deaths(mortality) in Kenya between 2010-2012	Morbidities i. Acute respiratory illnesses ii. Chronic respiratory illnesses iii. cancers
14.	Could you kindly give us the estimates of the following	i. The approximate estimate loss of man hours(sick offs) secondary to vehicle emission pollutants related illnesses ii. The approximate estimate cost of treatment of cases (respiratory illnesses and cancers) due to vehicle emission pollutants related illnesses iii. The approximate estimate loss due to deaths and lost work days

K. Estimated costs of vehicle emission pollutants related illnesses seen at KNH

S/No.	ITEM	Average approx cost/year (KShs)	Average approx cost/year (USD)
1	Outpatient charges including drugs/patient	600	7
2	Laboratory costs; Baseline investigations/ patient	1,700	20
	Logistical costs (e.g. bus fare/taxi etc.)	500	6
3	X -ray	700	8
	Ultra Sound screening	1,800	21
	CT scan	7,000	82
4	Hospital fee(Bed charges (…800…../day) for 5 days(hospitalization in severe cases)plus drugs and procedures	4,000	47
5	Follow up visits after admission/patient	500	6
Total		**16,800**	**197**

NB: *The figures above are based on assumption that the clients are treated in outpatient department once per year and admitted once per*

L. Recommendations related to regulations governing the Transport sector Recommendations, who is responsible and time frame

	Strength	Weakness	Recommendation	Managers	Time-span
1.	There is an 8 year manufacturing limit on the importation of vehicles.	**1.The limit is too long.** 2.The wear and tear of some classes of vehicles especially PSV's cannot be environmentally sustainable after continuous use.	• Limit the importation by further raising taxes on imported cars while encouraging local assembly by international manufacturers. • Cut the manufacturing time span from 8 to four years. • Ensure that all vehicle that exceed the 4 year manufacturing date have catalytic converters • Develop and strictly enforce vehicle standards and specifications (for PSV and private cars)	• KEBS • NEMA • Ministry of Trade and Industrialisation, • The Kenya Ports Authority	Implementation to begin in the next 36 months
2.	There is an established MVIU and Laws that dictate its terms of service. There is an established visual formula to evaluate the release of GHG's by a vehicle into the atmosphere.	A lot of GHG emissions are still occurring especially in the urban areas.	• Licensing of more private motor vehicle inspectors • On roads visual random inspection especially on Bus terminus and Weigh Bridges. • An increase in the capacity of the MVIU both within and out of urban areas to effective carry out inspections.	• Ministry of Roads and Transport • NEMA • MVIU • Kenya Police	
3.	Regulations are present and considerable enforcement against overloading commercial vehicles.	The present policy framework available is not enough to regulate emissions due to overloading of vehicles due to the manufacturing of the vehicles and Kenyan driving habits	• Mass dissemination to drivers can be encouraged to modify behaviors that unnecessarily increase consumption and thus emissions via including environmental studies in driving training programs that aim to convey better skills and habits. • Mass dissemination of education through the various media to the Kenyan population on the effects on emission on wrong driving habits	Ministry of Roads and Transport and the Police Traffic Department.	6 months

4.	Phasing Out of leaded fuel	Unleaded fuel still contains GHG emissions thus the need to use alternative fuel	• Adoption of new fuel blends that contain high ratio blending with diesel and petrol. Adoption of Low sulphur gasoline (sulphur content lower than 50 ppm).	Ministry of Energy.	48 months
5.	Legislation exists to restrict the operation of vehicles that are old, unroadworthy and release emissions	Many Kenyans still own old vehicles and lack the capital to buy new ones.	• Adoption of a buy-back system where vehicle owners will receive discounts on the return of old vehicles as a private-public partnership between manufacturers and the government.	The Ministry of Industrialisation and the Kenya Association of Manufacturers.	36 months
6.	There has been the construction of a Bus Raid Transit (BRT)System in Nairobi, and construction is ongoing in other major tons in the Country Existence of Integrated National Transport Policy: The adoption of the "Michuki Rules"	There is still congestion within the Central business district of most Towns in Kenya.	• An introduction of the Hybrid Diesel Euro IV Buses which will work to reduce emissions as they combine an internal combustion diesel engine propulsion with an electric propulsion. • Construction of priority lanes especially for Heavy Commercial vehicles. • The development of an urban transport policy • establish a Metropolitan Transport Authority (MTA)	The Ministry of roads and Transport	48 months
7.	There exists feebates within the current Kenyan legislation	The feebates are not exclusive to motor vehicles and emissions	A fiscal policy encouraging car buyers to prefer more efficient, lower emission vehicles with subsidies be offered to buyers of electric vehicles and plug-in hybrid models. In this regard the government should set a bench mark emission (e.g. in gCO2/km) and introduce rebate system to reward less polluting vehicles	The Ministry of Roads and Transport.	12 months

8.	There exists a functional efficient MVIU that carries out inspections throughout the country.	The current inspections are not sufficient to cater for the reduction of GHG's	• The MVIU should also make it mandatory for all car dealers to put a label showing the fuel consumption and CO2 emissions of each different model on display. • The motor vehicle inspection should be fully implemented as required by the existing laws. Moreover, a compulsory annual requirement for emissions tests on motor vehicles would be critical in ensuring that standards are maintained.	The Ministry of Transport and development	12 Months
9.	Existence of Vehicle Assembly industries in the country	Our motor vehicle technology is antecedent and we depend on other nations for innovation and developments. Kenya Lack a Biofuel Policy	The government should invest more in research o less polluting vehicle fuel technologies . Through is can be done by partial and full grants to universities to look into fuel cell chemical reaction chains, modes of achieving petroleum and **diesel blends among others.**	**Ministry of Industrialization and the Ministry of higher education**	**60 months**
		The current assembly of heavy commercial vehicles is such that it is not sufficient and environmentally sustainable	• The adoption of anti-idling systems by all truck assembling companies to all vehicles manufactured after 2015. • An adoption of the wide base tyres to replace the two tier tyre system. However, this should be approached warily with a particular caution as to the effect on the roads	**Ministry of Transport and Roads**	**24 months**

10.	Road traffic management information systems	There is insufficient and unreliable data for the efficient and effective traffic administration and adjudication. Fake documentation.	• Develop, implement, and maintain updated road traffic management information systems. • Establish National Transport Information System(NaTIS) at the NTSA. • Make available to NaTIS, other standardized databases for traffic related issues. • Computerize and interlink all the NaTIS Departments. • Computerize vehicle information.	**NTSA** **Ministry of Transport**	**12 months**