Energy Regulatory Commission

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

EMBRACING CLEAN FUEL FOR VEHICLE EFFICIENCY IN KENYA

PETROLEUM INSTITUTE OF EAST AFRICA PIEA

NTSA GFEI UNEP gef nema CCAC CLIMATE AND CLEAN AIR COALITION

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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 Kilometre
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
GFEG	Global Fuel Economy Guidelines
GFEI	Global Fuel Economy Initiative
GHGs	Greenhouse Gases
GMEA	General Motors East Africa
ICCT	International Council on Clean Transportation
IEA	International Energy Agency
IRR	Internal Rate of Return
ISO	International Organization of Standards
ITF	International Transport Forum
JCO8	Vehicle Fuel consumption measurement based on 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 Kilometres
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
NO_x	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 Kilometres Covered
WHO	World Health Organization
YLD	Years Lost due to Disability
YLL	Years of Life Lost

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Commendation also goes to the Task Team that supervised the study comprising staff from organizations such as the Ministry of Energy and Petroleum, Ministry of Transport and Infrastructure, National Treasury, National Environment Management Authority (NEMA), National Transport and Safety Authority (NTSA),

Kenya Bureau of Standards (KEBS), General Motors of East Africa (GMEA), Petroleum Institute of East Africa (PIEA), and the Energy Regulatory Commission. The names of the Task Team members are listed in Appendix 8.1.

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.

Pilot projects were 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 emission standards, energy security and fuel efficient goals.

In Kenya, UNEP collaborated with Energy Regulatory Commission (ERC) to undertake the pilot project. The ERC then commissioned the University of Nairobi Enterprises and Services Ltd (UNES) to carry out the study. During the study, the vehicle inventory data was analyzed to obtain the current fuel consumption and CO_2 emission levels. Subsequently, the survey of existing regulations in the transport sector, determination of health implications and Cost Benefit Analysis (CBA) were carried out.

The following broad aspects were studied:

(i) Vehicle Inventory

The records of registration of vehicles in Kenya for the years 2010, 2011 and 2012 were obtained from the Registrar of Motor Vehicles (RMV) which is a Department of Kenya Revenue Authority (KRA). The focus of the GFEI study is the category of

vehicles with a gross weight of less than 3500 kg. This category of vehicles is referred to as Light Duty Vehicles (LDVs). The data availed consisted of 300,094 LDVs with eleven descriptive variables for each model of vehicle. The variables included vehicle model, year of manufacture, fuel type, tare weight, usage, among others.

The pertinent 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 observations were made regarding the number of vehicles (including LDVs) registered since 2003.

1. The annual number of the LDVs registered had increased from 33,917 in 2003 to 110,474 in 2012.
2. On the basis of the trend during the 2003 to 2012 period, projections of the cumulative total vehicle registrations predicted a vehicle population of 5 million in 2030 and 8.7 million in 2050.
3. The predominant engine displacement of the registered vehicles is that of 1500 to 2000 cc (35%) of the registered vehicles, followed by capacities above 2500 cc (19%) and those with engine capacity below 1300cc (7%).
4. During the period under study 84% of the vehicles (LDVs) were manufactured in Japan and 10% in Germany.
5. The bulk (67%) of the LDVs registered during the period of study was seven (7) to eight (8) years old.

The average fuel economy was established as 7.5 L/100km compared to the global average of 7.2 L/100km and the average CO2 emission was 181.7g/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 increased social costs whereby increase in 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 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 policy emphasizes the use of lead free and low sulphur fuels. The Policy stipulates the domestication of efficient and less polluting fuels. It also provides strategies of dealing with Public Service Vehicles as far as proper maintenance, air 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 Authority, 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 the Authority 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 2060:2012 – Motor Gasolines - Specification

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

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

This Standard specifies maximum requirement of Sulphur content as 0.05%.

It should be noted that the Kenya Standards on diesel and petrol will be superseded by the harmonized East Africa Standards which have better/higher specifications e.g. 50ppm sulphur content in diesel and 93 research octane rating for petrol. This will be effected from 1st January 2015.

The limitations and impact of these and other existing regulations are determined by the process of enforcement and implementation. Thus, 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 emissions and the average fuel consumed per kilometre are necessary to improve on vehicle fuel efficiency. Based on the 2012 data 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" is designed to achieve 50 per cent reduction in the average CO_2 emission and fuel consumption by the year 2050.

The study proposed and evaluated several policy interventions which could promote attainment of the targets. The CBA methodology was based on a public welfare perspective and 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 specific 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.

At the national scale, fuel sales data in 2012 for Motor Spirit Premium stood at 618500 tonnes, while sales for light diesel fuel was 148600 tonnes (Statistical Abstract, 2013). Data from the Economic Survey 2014 reveals that in 2012, the total sales from retail pump outlets and road transport stood 2,234,700 tonnes. Conversion of these sales data using average retail pump prices reveals an estimated expenditure of Kshs 330 billion on petroleum fuels. However, based on data from the Vehicle Inventory prepared by the study team (which captures a fraction of the total national vehicle population), it is found that at the current fuel economy level

(7.61 L/100km), it costs the economy approximately KShs 30 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. 21 billion p.a. Concurrently, 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 below were subjected to Cost Benefit Analysis and the adoption of a policy mix yielded highest savings while vehicle options as stand-alone had higher impacts than stand-alone tax options. Other fuel efficiency options considered are also illustrated.

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 CO2 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 with focus on the prevalence of respiratory diseases related to air pollutants which was greater than 90% in 2010, 2011 and 2012. The burden of the respiratory diseases is quantified by the measure referred to as Disability Adjusted Life Years (DALYs) which represents the incident number of healthy life years lost due to disease or disability. DALYs was computed as 20,639,387 years, which has large implications on productivity since many active years are lost.

(iv) Recommendations

The following recommendations were made from the study:

a) Vehicle Inspection

The Motor Vehicle Inspection Unit should develop capacity to:

- Conduct regular inspection for vehicle safety, roadworthiness and exhaust 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 National Treasury should establish mechanisms to:

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

c) Infrastructure and transport planning

The Ministry of Transport and Infrastructure should establish a framework for provision of mass transit (Bus/Train) to enhance a shift from private car dominance and provide for Non-Motorized Transport modes i.e. bicycles lanes, special lanes for cart-pooling and pedestrian lanes.

d) Health surveillance

Ministries of Health and Environment should establish frameworks to:

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

e) Vehicle and fuel Standards

National Transport and Safety Authority should establish a framework to:

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

1.0 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 the most fuel efficient technology and enabling policies are adopted across the globe (FIA Foundation, 2009).

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 achieving 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.

According to the National Geographic magazine (2007),

- 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.

- 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.
- 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.
- Carbon Dioxide (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 established 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 between 2010 -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 CO_2 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 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 laws, regulations and policies and incentives to promote cleaner and fuel efficient vehicles and recommend appropriate interventions.

c) Conduct Cost Benefit 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) Give the population of people who suffer emission related illnesses (2010-2012)

   (iv) Give the 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 by a National productivity index due to deaths and lost work days/idle times 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 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 during the period 2010, 2011 and 2012, was compiled and analyzed.

2.0 VEHICLE INVENTORY

2.1.Approach

The team adopted a participatory, collaborative and integrated approach as per the Global Fuel Economy Guidelines (GFEG). 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. The Registrar of Motor Vehicles at Kenya Revenue Authority (KRA) was contacted for primary source of vehicle inventory data. The data was cleaned for 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 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) 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.

The key stakeholders consulted included: Energy Regulatory Commission (ERC), the United Nations Environment Programme (UNEP), National Environment Management Authority (NEMA), 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, 2011 and 2012. A total of 300,094 LDVs were registered LDVs of which 1%were classified as new while 99% of the vehicles were imported after initial use in the countries of origin i.e. used vehicles.

2.3.Vehicle Registration Data

Descriptive variables of each model of vehicle included the following:

(i) Number of 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 manufacture
(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 (IEA, 2012). The key variables for vehicle inventory according to IEA data frame consists of 24 attributes (Climate XL Africa, 2011). 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 were however incomplete since they did not include names of models and types of transmission. Until recently, fuel consumption of vehicles with automatic transmissions were up to 10% higher than those with manual transmission. Technically, this was attributed to their extra weight, fewer gears and inherent torque converter inefficiencies. As the preference for automatics increased, accelerated development has largely overcome the above draw backs (Van Dongen , 1982; Ramsay, 2010).

Since available data did not specify the type of transmission, the study assumed the local 14 passenger seater (matatu) and commercial vehicles to be typically of manual transmission and established their fuel consumption accordingly.

2.4.Data Cleaning

Cleaning of data involved removal of errors in the acquired vehicle data and it entailed:

a) Removal of vehicles not classified as light duty from the data base. Vehicles discarded included heavy duty commercial vehicles, big buses and trucks.
b) Separation of new and used vehicles.
c) Rectification of data entry errors e.g., spelling mistakes.
d) The list as availed did not identify model 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 on fuel economy and CO_2 emissions as sources on websites are predominantly based on model names.

Though motorcycles have a gross weight of less than 3500 kg, their fuel economy and CO_2 emissions are of different order of magnitude and are typically excluded from classification as light duty vehicles.

However, in the present study, it was considered expedient to separately highlight their excessive contribution to deterioration of urban air quality.

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 as a standard procedure before authorization of the same for sale. The test methods including test cycles used 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 the present study, the data sourced was based primarily on US, European and Japanese test cycles, namely, CAFE, NEDC and JC08 test cycles respectively.

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[1].

b) 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.

c) 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.

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

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. The trend of used and new LDVs registered for the period 2010- 2012 is indicated in Table 2-1.

Table 2-1: 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**

The trend of total number of LDVs registered for the period 2003 - 2012 is indicated in Table 2-2 below.

Table 2-2: 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*

These are total registered vehicles (everything). Explains big drop in 2010 when now truly LDVs.

The data from table 2-2 was plotted on a linear graph for ease of projection.

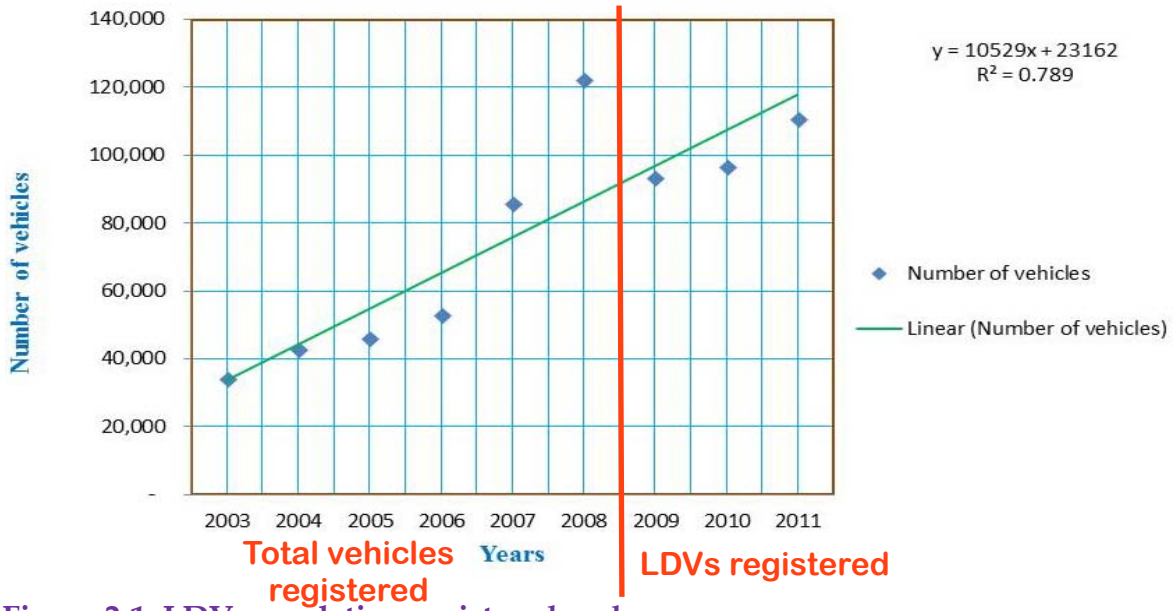

Figure 2-1: LDV population registered each year

Tables 2-1, 2-2 and Figure 2-1 show 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 2-3: 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

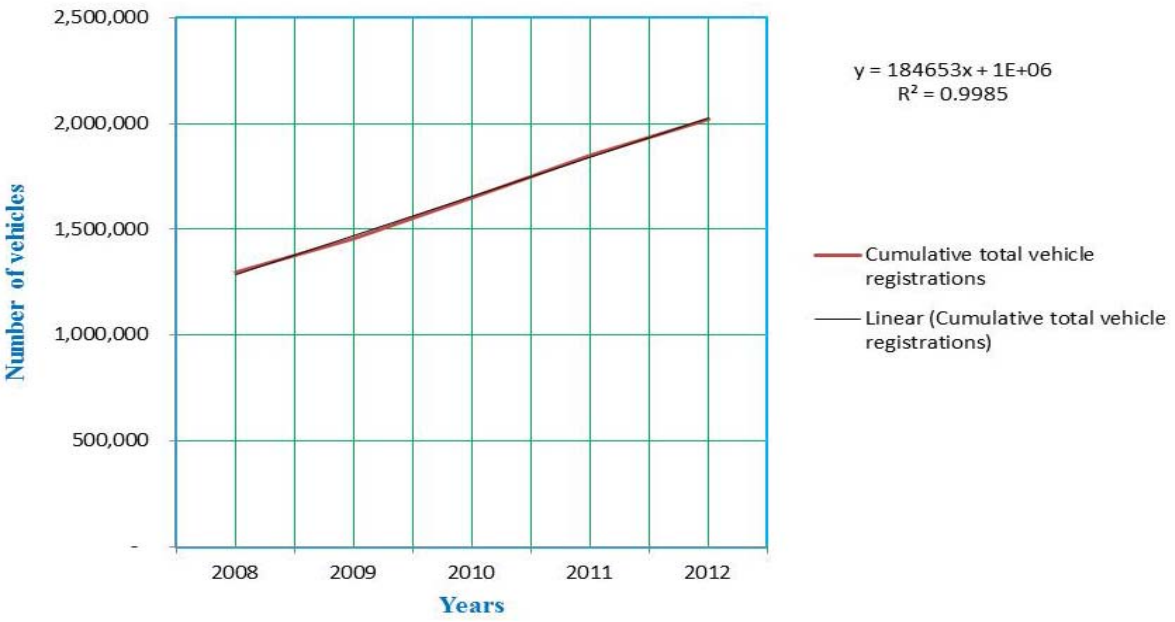

Figure 2-2: Cumulative Total Vehicle Population Registered in Kenya

Table 2-3 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 data 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 under linear extrapolation. Exponential growth estimates would return much larger figures, if the indicators of economic growth were to mimic exponential growth.

The most prominent effect of a high rate of registration of vehicles will be manifested in large cities. In much of the developing world the number of motor vehicles is increasing at more than 10% per year. The significance of such high rate of motorization is that related systems such as infrastructural development like road network cannot keep pace with it (Gakenheimer R. 1997).

Omwenga (2011) estimated the motor vehicle population in Nairobi to be 30% that of the national figures and established the rate of increase in number of vehicles in Nairobi as 11.3%. A study (Odhiambo et al, 2010) on the level of air pollution in Nairobi indicated the mean day time concentrations of fine particles to be considerably high and ranging from 10.7 µg/m^3 (at the rural edge of the city) to 98.1

µg/m^3 on the sidewalk in the central business district. Exposure of the general population to levels above 46µg/m^3 is considered to increase risk of respiratory diseases (Air Quality Ontario, 2010).

Table 2-4: 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 2-4 and Figure 2-3 display registration of vehicles by engine displacement and fuel type. It was observed that the preferred engine displacements (size) were in the ranges of 1301-1500 cc and 1501-2000 cc, which together constitutes 72% of the light duty vehicles. Table 2.5 shows light duty vehicles powered by petrol to constitute 86% and those powered by diesel only 14%. Today's diesel vehicles are much improved over those of the past. They are more powerful and fuel efficient than similar sized gasoline engines (about 30% - 35% more fuel efficient). This is due to improved fuel injection and electronic engine control technologies. New engine designs, along with noise and vibration damping technologies have made them quieter and smoother (Fuel Economy – Diesel Vehicles, 2014).

In Great Britain and other European countries the effort to reduce energy consumption and CO_2 emissions in the transport sector through dieselization resulted in increased ratio of road diesel to gasoline from 0.75 in 1990 to 2.5 in 2014. The term dieselization represents the percentage share of diesel cars in the total car fleet. (European Commission, 2013). According to Table 2-5 the local market is not

responsive to dieselization and during the period of study the road diesel to gasoline ratio actually decreased from 0.2 in 2010 to 0.14 in 2012.

The absence of a trend with regard to dieselization was attributed to the primary source of vehicles in the local market. Approximately 90% of the light duty vehicles are imported from Japan, where the hybrid (electric and petrol) vehicle is promoted in preference to diesel cars.

Table 2-5: 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**

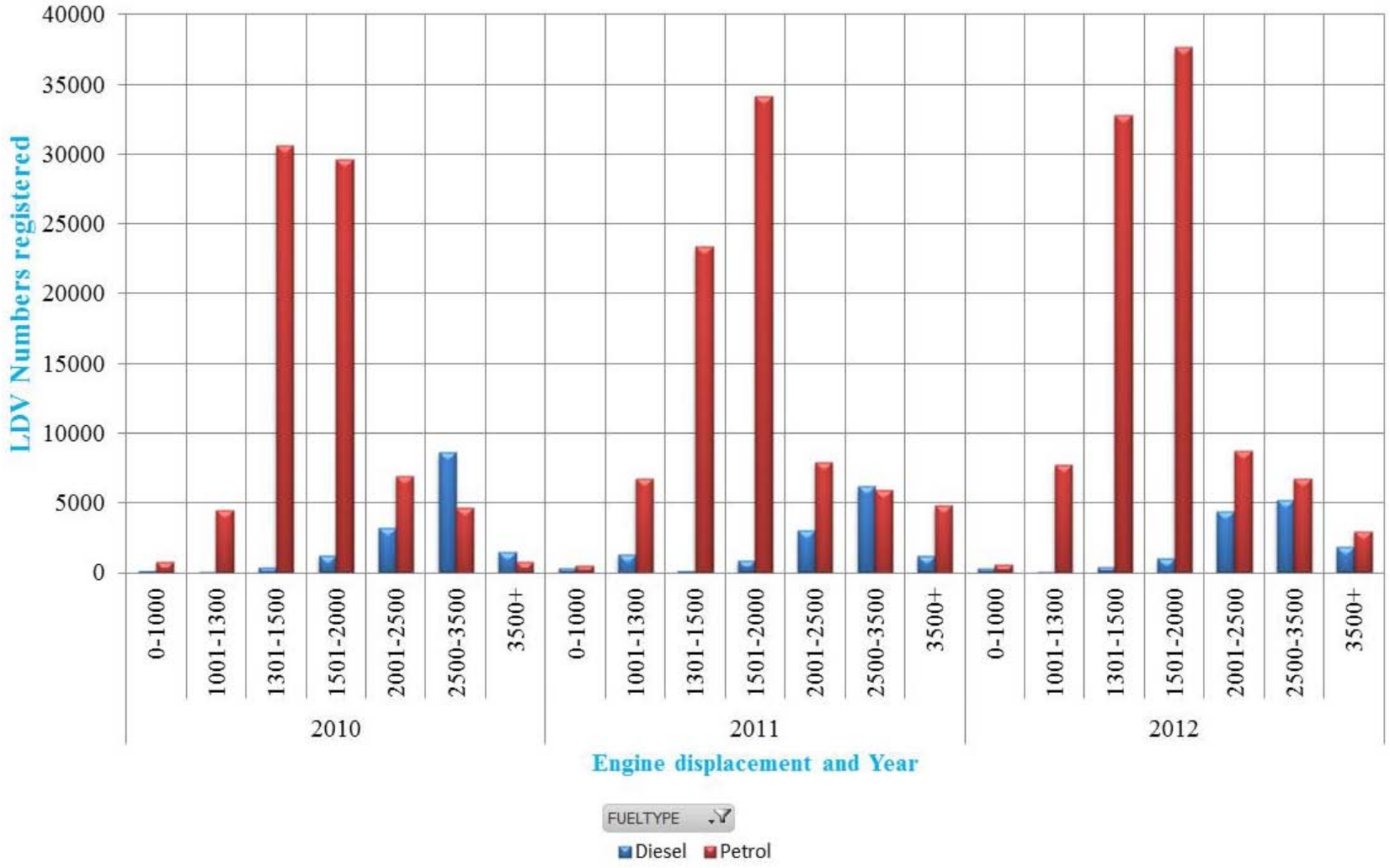

Figure 2-3: Registration of LDVs by engine displacement and fuel types

Table 2-5 summarizes the percentages of vehicles by fuel type and indicates that approximately 86% of LDVs registered between 2010 and 2012 were powered by petrol engines compared to diesel powered types which averaged 14% of the total 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 computing 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 Governments' websites. The test cycles (i.e. vehicle running patterns) used in US, Europe and Japan are CAFE, NEDC and JC08 respectively. Using the methodology developed by International Council on Clean Transport, the values from the various test cycles were converted to corresponding values in NEDC (ICCT, 2007).

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

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

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

Table 2-6: 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 2-7 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 2-7: 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**

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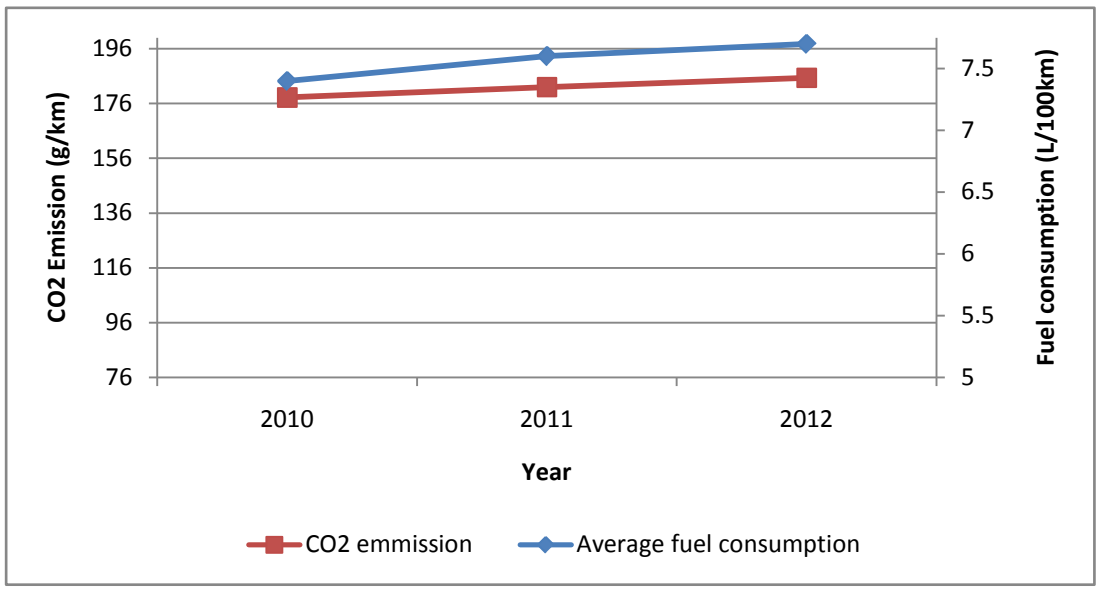

Figure 2-4: Trends in Fuel consumption and CO_2 emission over the period 2010 to 2012

Table 2-8: 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**

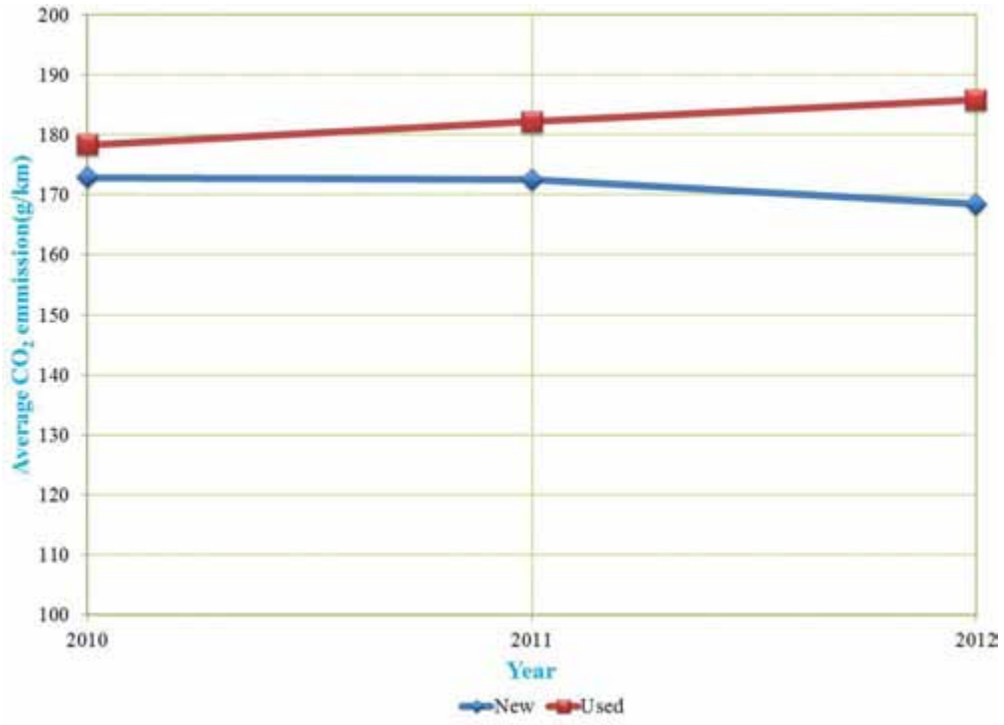

Figure 2-5: Trends in CO_2 emissions over the study period, 2010-2012 for new and used vehicles

New vehicles were observed to have lower CO_2 emission and fuel consumption as compared to used vehicles as shown in Table 2-8 and Figure 2-5 for CO_2 emission levels and Table 2-9 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 2-9: 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**

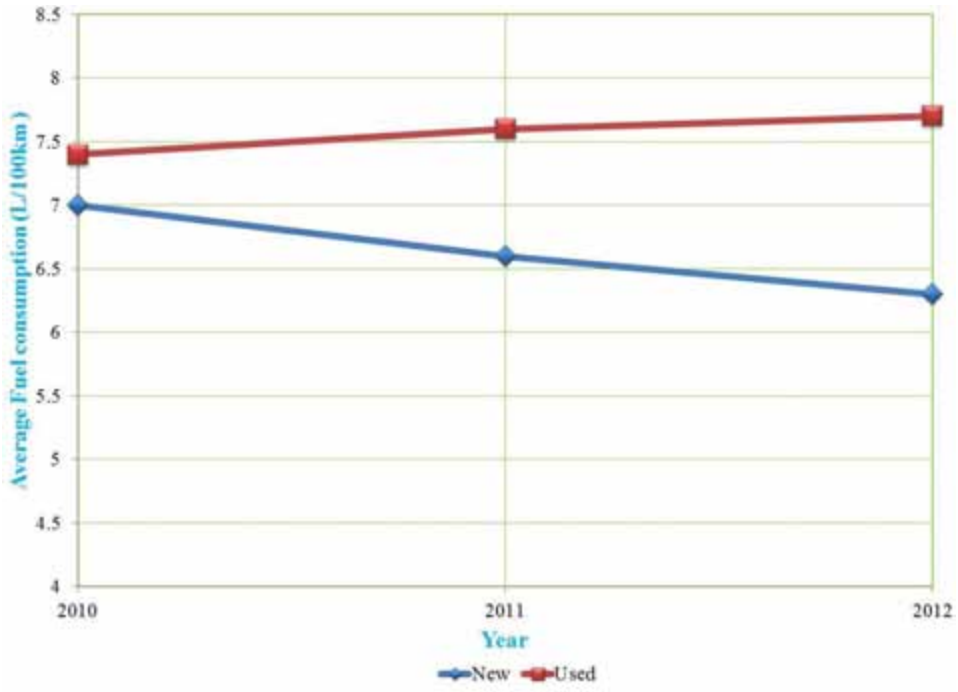

Figure 2-6: Trends in Fuel Consumption levels for new and used cars (2010-2012)

Light duty vehicles with diesel engines were noted to have an average consumption of 8.0L/100km while the petrol powered had an average of 7.4L/100km.

Since diesel engines are more fuel efficient than similar sized gasoline engines, the fact of a higher fuel consumption affirms that as the size of engine increases diesels engines become more common. This higher fuel consumption could also be attributed to

increased popularity of larger heavier vehicles with large diesel engines in the form of sports utility vehicles.

Table 2-10: 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

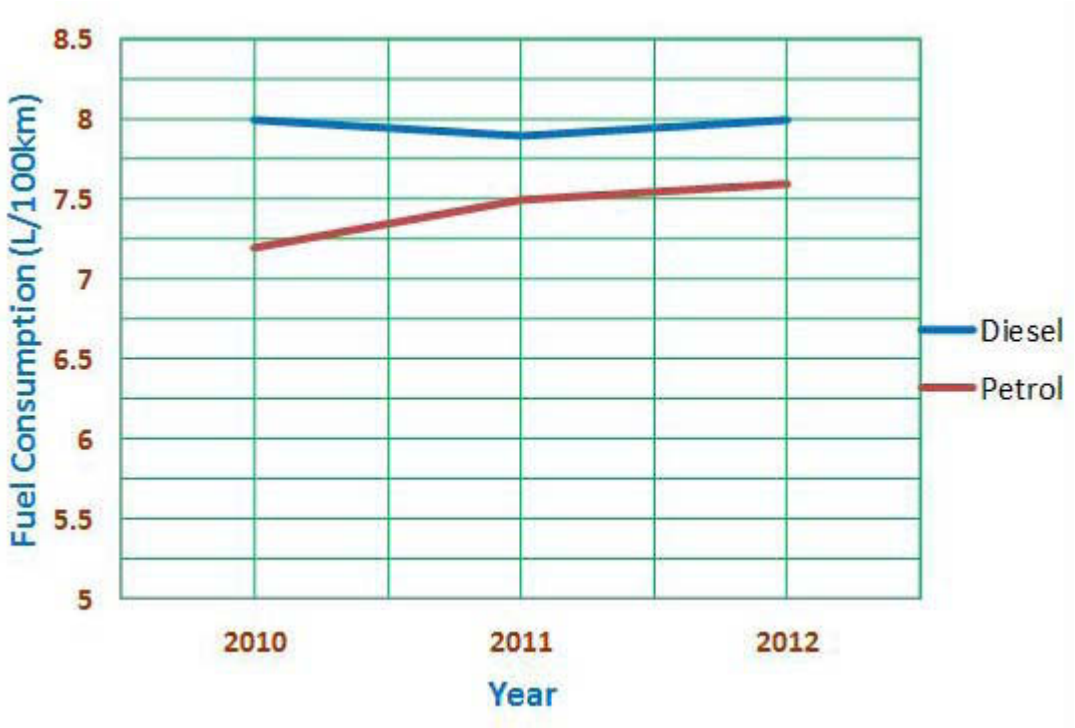

Figure 2-7: Trends of Average Fuel Consumption for Diesel and Petrol powered vehicles

Table 2-11: 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**

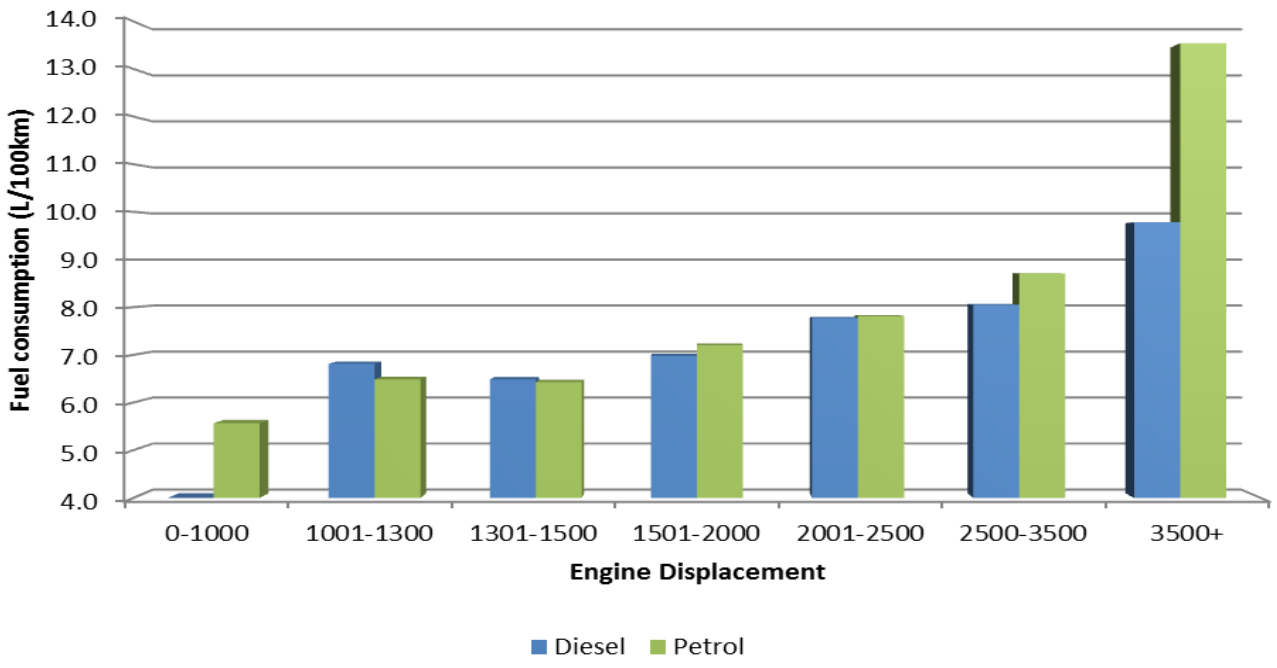

Figure 2-8: Fuel Consumption levels by fuel type and engine displacement

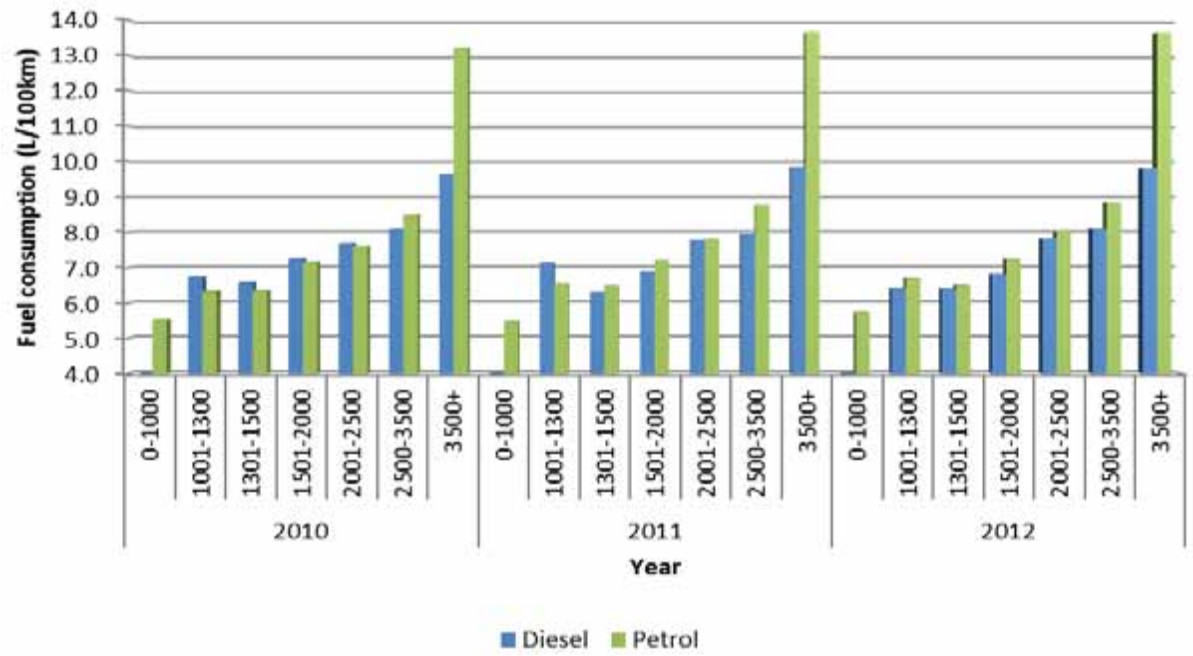

Figure 2-9: Average Fuel Consumption for Diesel and Petrol Engines by Vehicle capacity

Table 2-12: 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 2-12 and Figure 2-10 also show fuel consumption to be directly proportional to that the vehicle tare weight. Hence the industrial trend to replace 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).

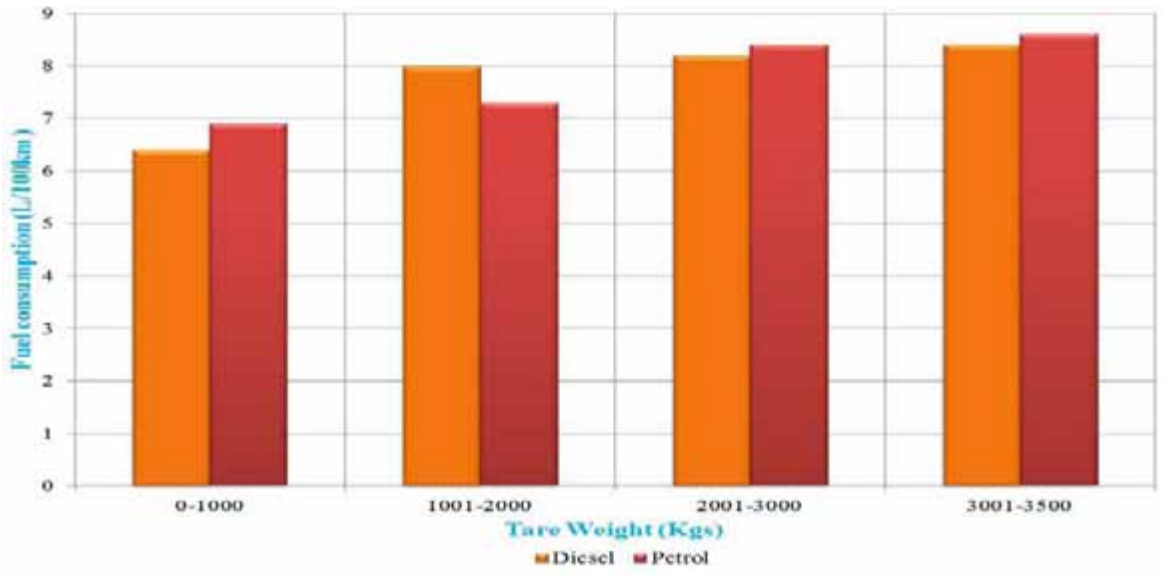

Figure 2-10: Average fuel consumption in L/100km by vehicle Tare weight

2.9.Average age of Registered Vehicles

Table 2-13 and Figure 2-11 shows the number of vehicles registered during 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.

Table 2-13: 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**

Can one get raw data?

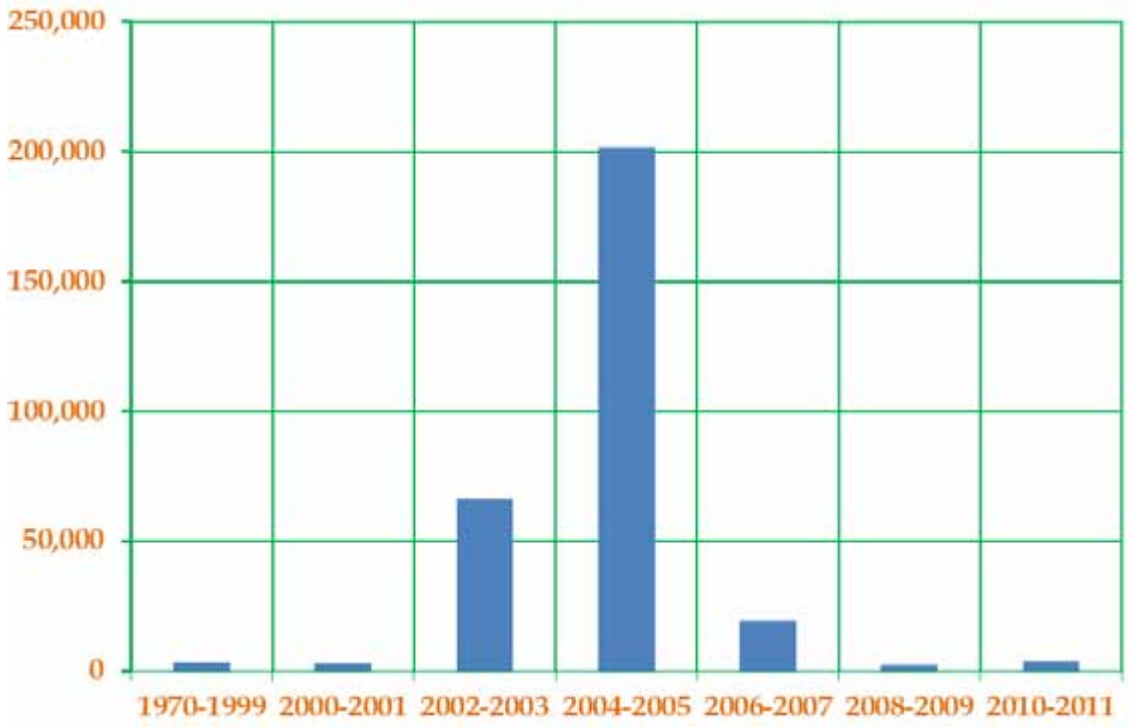

Figure 2-11: The number of vehicles registered and year of production

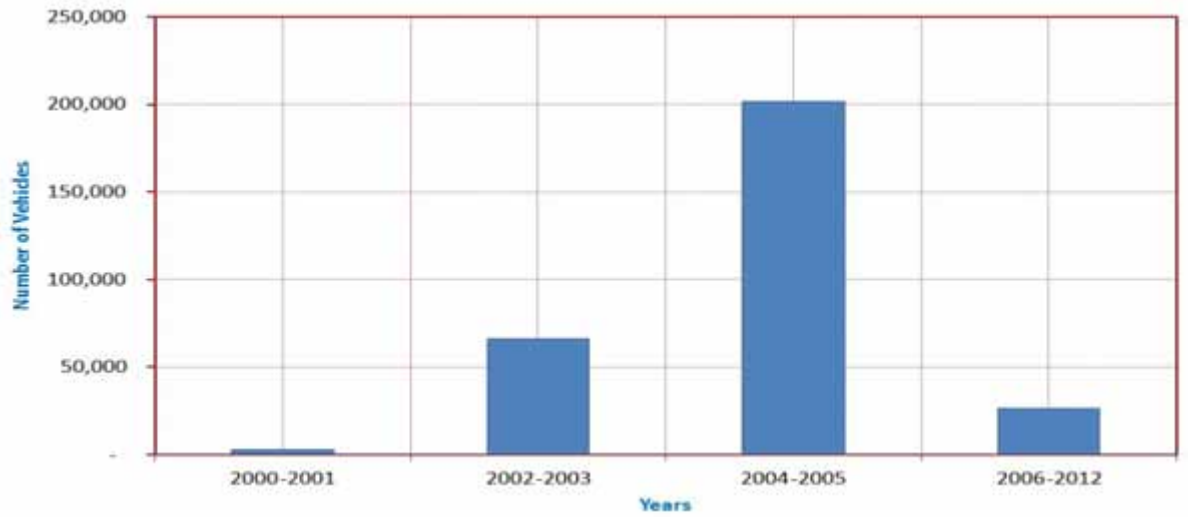

Figure 2-12: The number of vehicles registered and year of production

2.10. Make of Vehicles, their CO_2 and Fuel Consumption

Table 2-14, Figures 2-13 and 2-14 provide data on the different makes of vehicle by 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. The information is extracted from the data and does not contain the manufacturers' specifications about the specific vehicles. The data merely presents a summary of the emission and fuel consumption for the vehicles registered in the local market in Kenya, within the study period.

Table 2-14: 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**

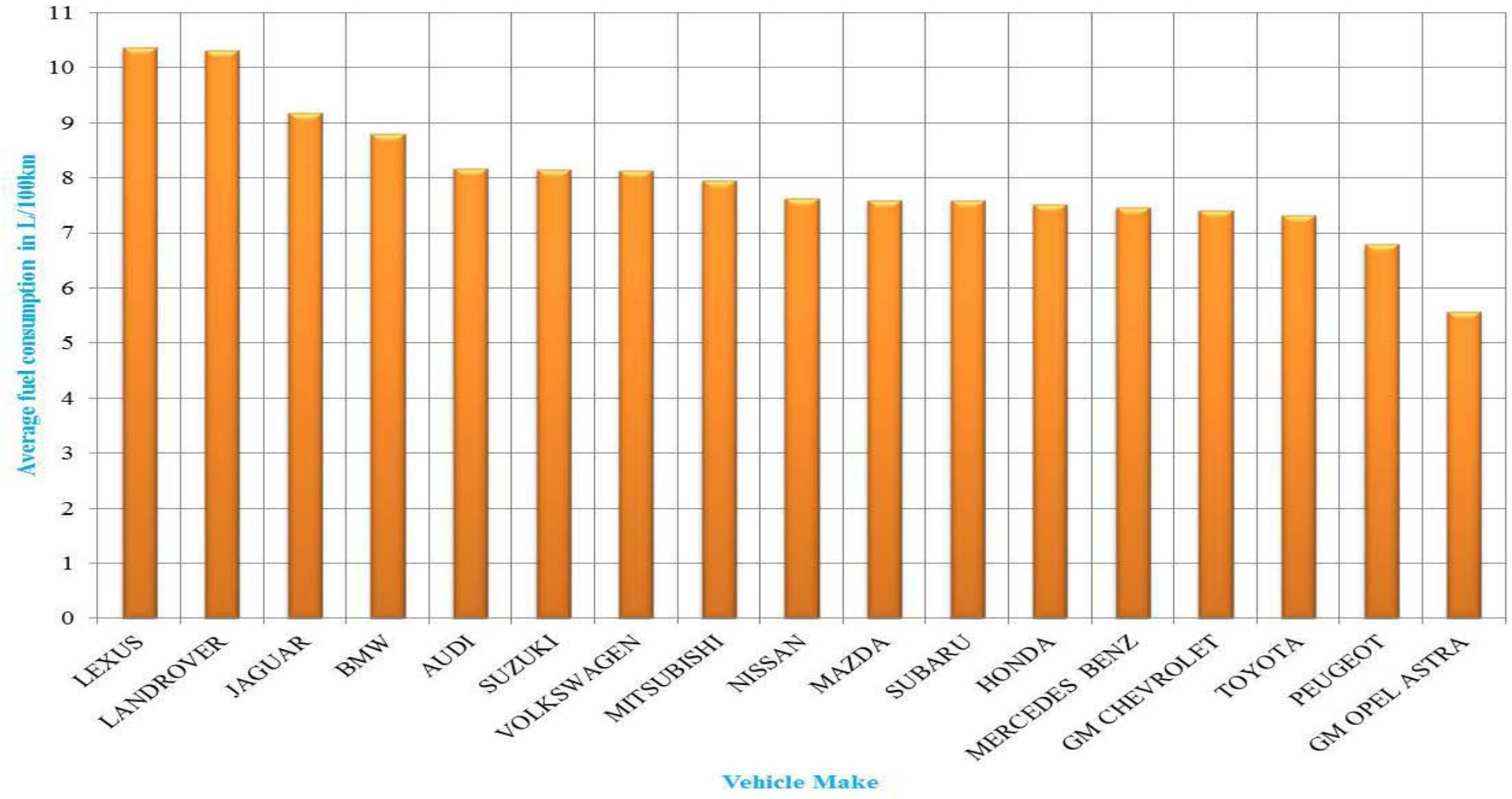

Figure 2-13: The average fuel consumption in L/100km by Vehicle make

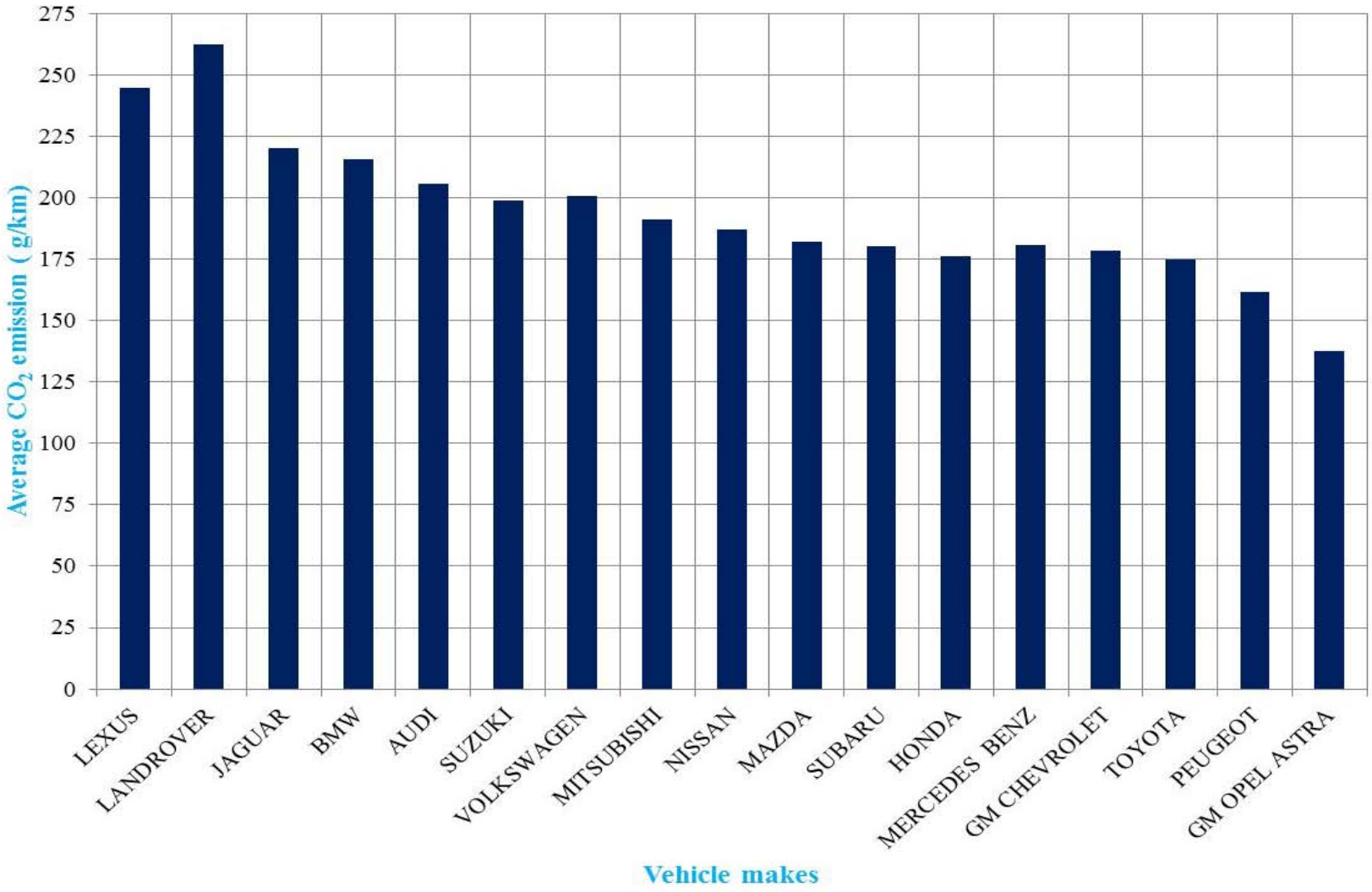

Figure 2-14: The average CO_2 emission in g/km by Vehicle make

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 over 95% 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. Figure 2-15 (ICCT, 2009) shows Japan and Europe as leading in restriction in the growth of emissions through fuel economy. The profiles from local studies by climate XL Africa (2008) and that from the present study have been superimposed for comparison.

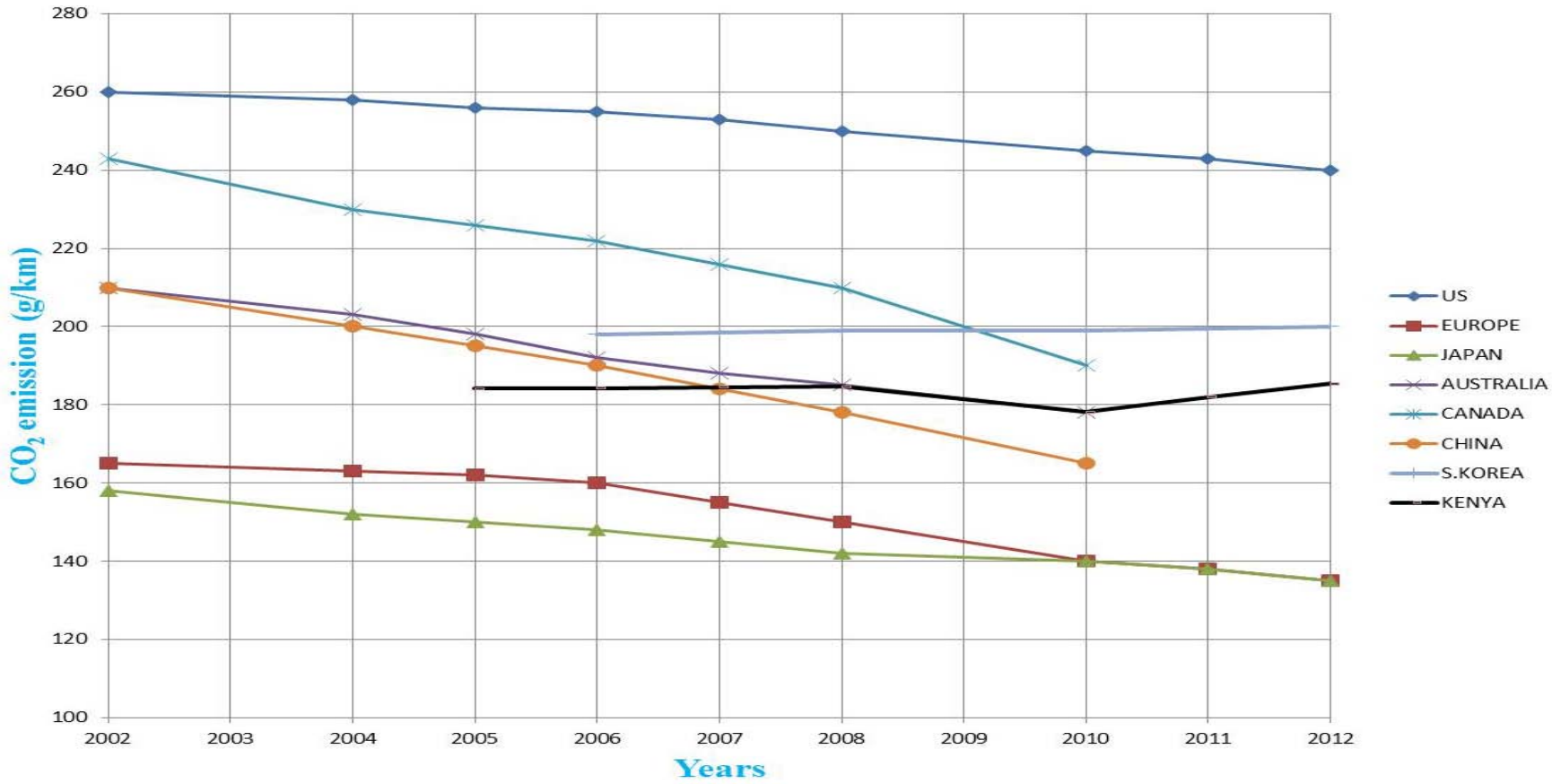

Figure 2-15: The average CO_2 emission in g/km for selected countries (ICCT, 2009)

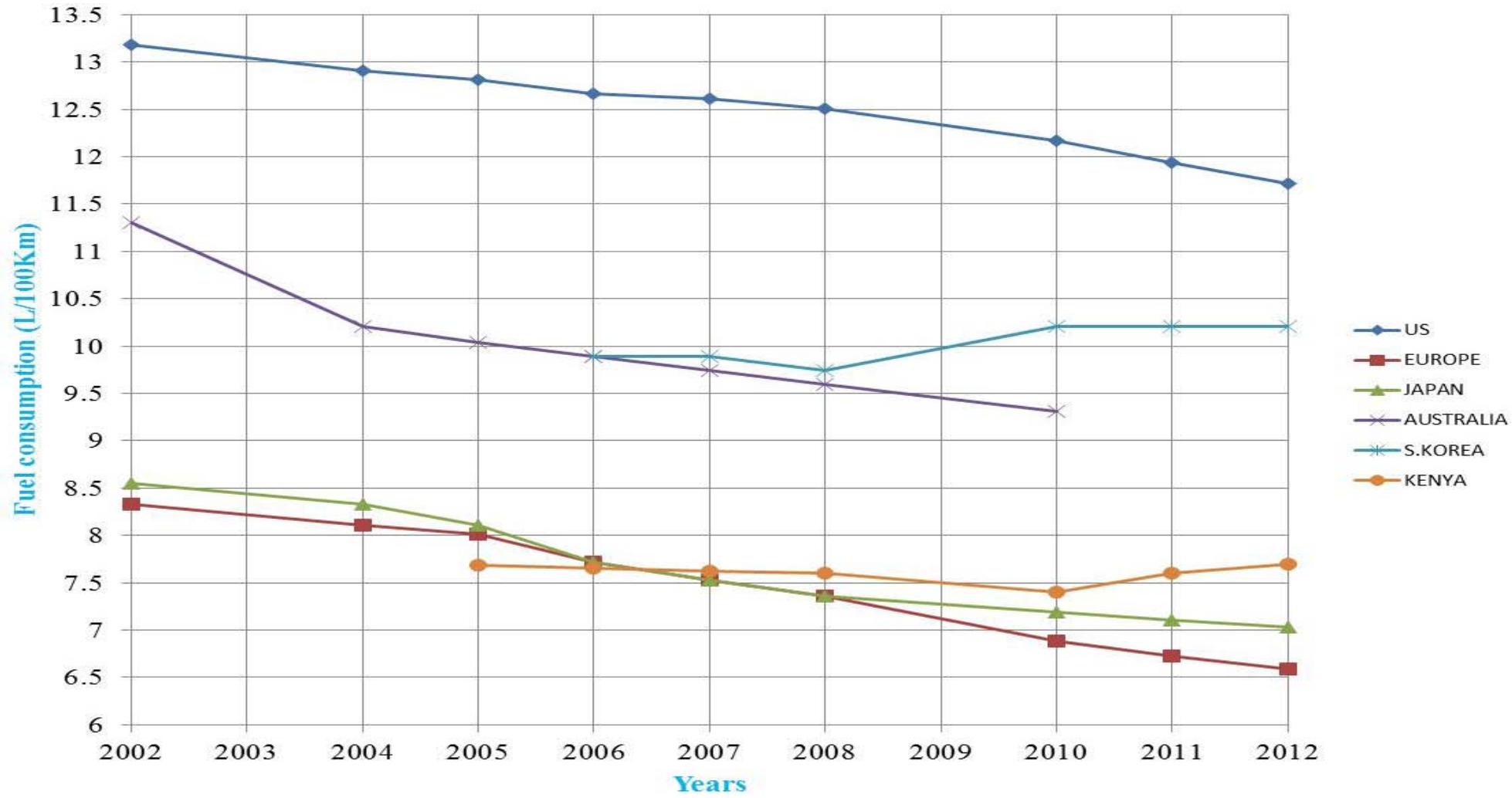

Figure 2-16: The average fuel consumption in L/100km for selected countries (ICCT, 2009)

According to Table 2-15 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 between 2002 and 2004.

According to Figure 2-16, the fuel consumption figures for vehicle fleet in Kenya during the period of study compares with the scenario in Japan during the period 2005 – 2007. Since the average age of vehicles imported into the local market in 5 years, the vehicles in focus during the study period of 2010-2012 were part of the fleet in Japan during the 2005 – 2007 periods.

Table 2-15: 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**

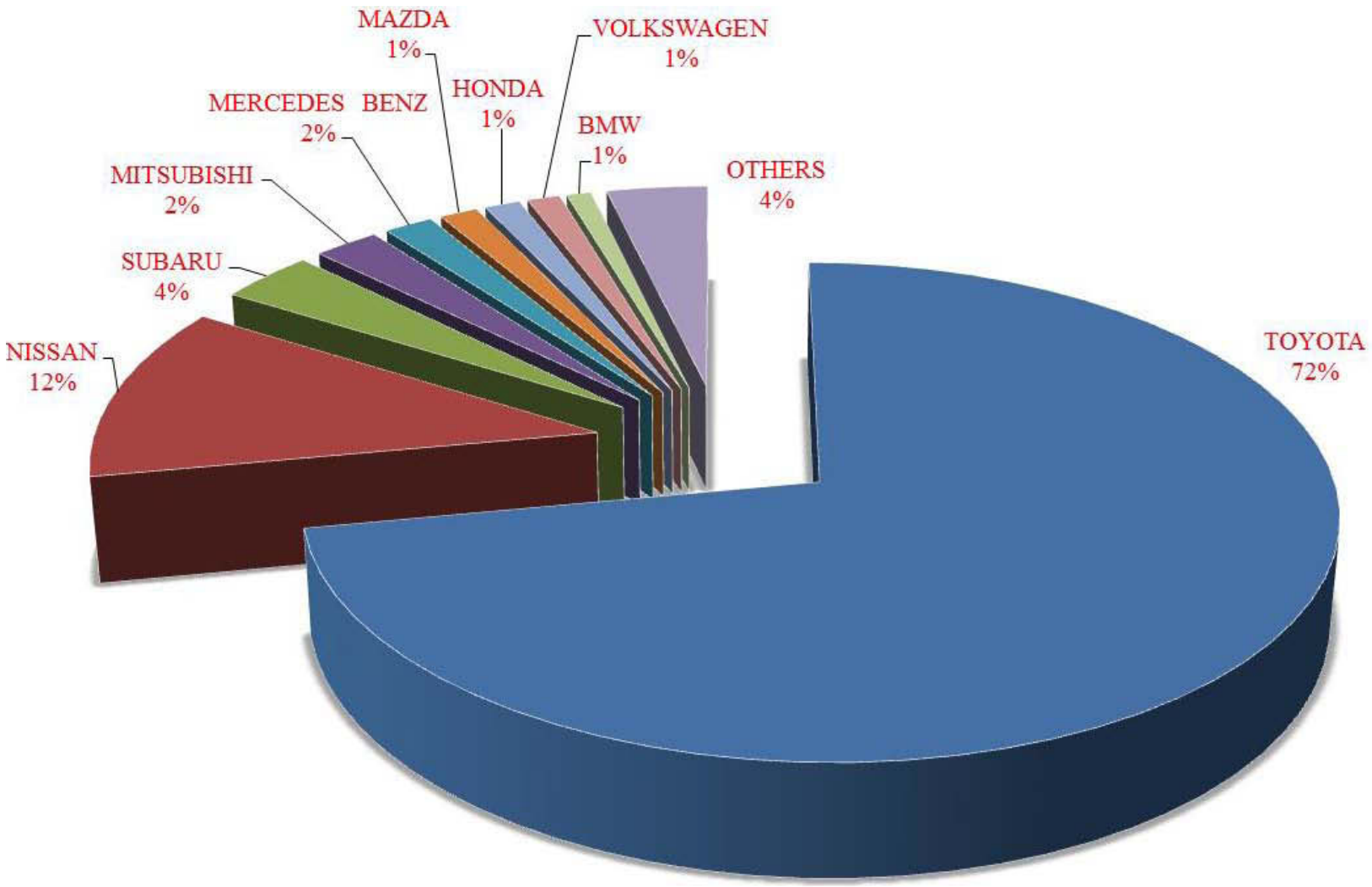

Figure 2-17: Percentage of vehicles on Kenyan roads (by make) registered during the period 2010-2012

2.12. Vehicle Technology and Infrastructure

The general trend (worldwide) is of continued improvement on fuel economy and reduction in the average CO_2 emission. This is based on the following observations (FCAI, 2011):

- 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 in terms of rail and road networks and overall traffic management.

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 must include reducing kilometers travelled, reducing the number of vehicles on the road and improving the entire vehicle fleet to result in larger, cost effective CO_2 emission reduction from road transport (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. A limited number is in the databank of KRA. The numbers registered during 2010-2012 period is shown in Table 2-16. It is also

noted that as of 2012 the Government exempted duty on all vehicles classified as hybrid (Budget, 2011).

Table 2-16: 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 2-17: 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 (UK-VCA, web 2014).

Table 2-18: 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**

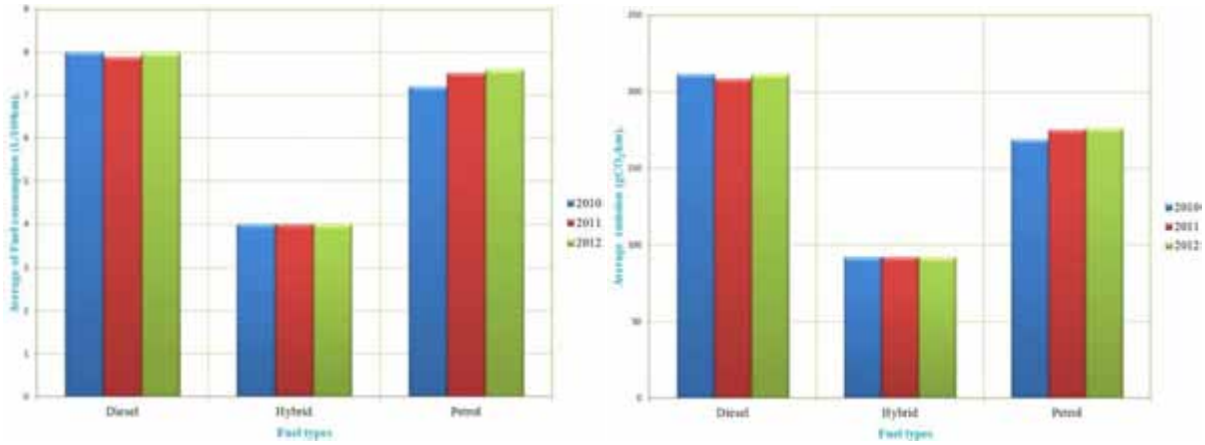

Figure 2-18: Average Fuel consumption (L/100km) and emission (gCO_2/km) by fuel type

2.14. Motorcycles Inventory

Since 2005 the number of motorcycles registered locally has manifested substantial growth. This is attributed to their convenience and accessibility as motorized transport. Figure 2-19 shows the dramatic and sudden change in the number of motorcycles registered during the period of study against LDVs. Though the population of motorcycles is less than that in 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.

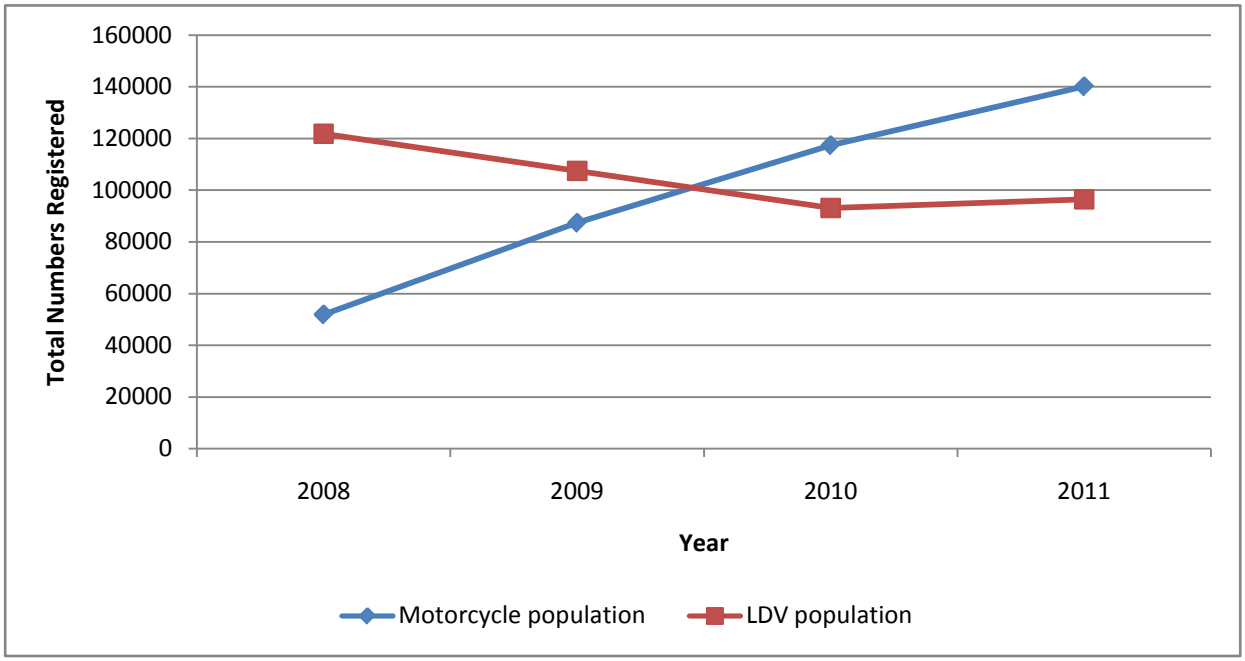

Figure 2-19: Number of motorcycles vis-à-vis number of LDVs in the period 2008 to 2011

2.15. Motorcycle Engine Technology and emissions

The motorcycle engine has traditionally been both two and four stroke models. The carbureted two stroke engines have been used where efficiency is not of primary concern with the merit of engine simplicity which translates into lower cost and higher power per unit weight. Familiar scenarios where these are advantageous are; 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 (UNEP Articles, Leapfrog Factor, 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 models. 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 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 in Table 2-19.

Table 2-19: 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 increased 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. Urban Air Quality

Vehicle emission is one of a number of contributing factors to urban air quality. In terms of the health impacts, four pollutants of particular concern are; Particulate Matter (PM), Hydrocarbons, Carbon Monoxide and Sulphur Oxides (SO_x). These emissions depend very much on the fuels used and vehicles design.

The main contributor to lower emissions in developed countries has been the introduction of cleaner fuels along with the introduction of improved engine technology and after treatment devices.

The introduction of unleaded petrol has paved way for after treatment systems especially catalytic converters. Similarly, introduction of low-sulphur diesel fuels have made the introduction of after-treatment technologies possible for diesel engines (UNEP 2002). The average emissions of HC, CO, PM and NO_x per km used in the study for petrol and diesel vehicles are given in Table 2-20.

Table 2-20: Average emission of HC, CO, HC, NO_x and PM

Vehicle	Carbon Monoxide CO(g/km)	Hydro Carbons HC(g/km)	Nitrogen Oxides NO_x(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, 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 (UNEP, 2011).

There are a number of 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 National Environment Management Authority (NEMA) and 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 (UNEP-CCAC Press, , 2010).

Furthermore, the Kenya Standards on diesel and petrol will be superseded by the harmonized East Africa Standards which have better/higher specifications e.g. 50ppm sulphur content in diesel and 93 research octane rating for petrol. This will be effected from 1st January 2015.

2.19. Findings and Discussions

1. During the assessment period, the following were the findings:
   a) The number of motor vehicles registered was 93,138, 96,484 and 110,472 for the period 2010, 2011 and 2012 respectively. On the basis of the best line of fit a total of 307,445 LDVs would be registered in 2030 and 518,025 LDVs in 2050.
   b) The LDVs over the assessed period had an average fuel economy of 7.5L/100Km and 181.7gCO_2/Km. The fuel economy for diesel was 8 L/100Km and 7.4/100Km for petrol vehicles.
   c) The fuel economy for fuel efficient vehicles such as hybrid vehicles was about 4L/100Km.
   d) One (1) percent of registered LDVs were new while ninety nine (99) percent were used vehicles.
   e) Eighty six (86) percent of registered LDVs were petrol powered while fourteen (14) percent were diesel powered.
   f) It was noted that the fuel economy decreased with increase in Tare Weight.
   g) About 67% of the vehicles imported in 2004 - 2013 period had an average age of 7 to 8 years.
   h) It was observed that the preferred engine displacements (size) were in the ranges of 1301-1500 cc and 1501-2000 cc, which together constitutes 72% of the LDVs.
   i) The number of motorcycles registered increased exponentially from 51,855 in 2008 to 140,153 in 2011.
2. The present study did not identify any emerging trend in choice of technology, fuel preference and legislative framework purposed as a measure of regulating fuel economy and emissions. In Great Britain and other European countries there was an increase in the percentage share of diesel cars in the total passenger car fleet. The phenomenon referred to as dieselization is primarily based on the better fuel economy of the diesel engine over that of a petrol engine of the same capacity. Over 90% of the vehicles in the local market are manufactured in Japan where the hybrid/electric vehicle is promoted in preference to diesel cars. As such the absence of a similar trend in the local market was considered unusual.

3. The presence of a large population of motorcycles is identified to have social costs in the form of contribution to deterioration of the environment and increased accidents. Additionally and particularly in the urban environment, motorcycles are a significant source of particulate emissions, hydro carbon and carbon monoxide.
4. The study noted that the most promising and feasible method suitable for immediate implementation for improvement of fuel economy and reduction of CO_2 emission is the use of cleaner fuels. It is cheaper to improve conventional fuels as no investment is needed for new storage tanks and service stations.

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 factors; in its simplicity it projects a potential environmental challenge.
2. Petrol engines were established as most prevalent with the preferred engine size in the range of 1300 to 2000 cc.
3. The absence of electric/hybrid vehicles was considered unusual and was attributed to inadequate general public awareness on fuel efficiency matters.
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 i.e. their contribution to deterioration of urban environment and increase in number of accidents was highlighted. The use of two stroke engines in motorcycles is discouraged on account of poor emission characteristics and high fuel consumption. 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.

5. Enforcement of vehicle maintenance and inspection standards for all motorized vehicles would improve safety on the roads.

3.0 REGULATIONS AND STANDARDS

3.1.Legislative Framework

The Constitution of Kenya 2010 has enhanced protection and enforcement of fundamental rights amongst other gains. One of these is the right to a clean and healthy environment. Numerous regulations and incentives are in place to promote cleaner and fuel efficient vehicles. These cover emissions, inspection, catalytic converters, taxation and other technologies. The paragraphs below outline various policies, laws, plans and strategies that address these issues.

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 to hazardous air pollutants. 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 the harmful pollution.

3.1.1.1. The Environmental Management and Coordination Act (EMCA), 1999

The EMCA provides for a comprehensive ***Penal, Regulatory, Supervisory, Fiscal and Institutional framework.*** Section 82 of the EMCA prohibits use of motor vehicle in such a manner as to cause air pollution by contravening the established emission standards. It also prohibits importation of machinery or equipment that may cause emissions into the ambient air in contravention of prescribed emission standards. Section 57 of EMCA provides that the Minister responsible for finance may, on the recommendation of the Council, propose to Government tax and other fiscal incentives, disincentives or fees to induce or promote the proper management of the environment and natural resources or to prevention of environmental degradation.

The EMCA created several statutory bodies which include the National Environment Management Authority (NEMA) and Standards Enforcement and Review Committee (SERC). NEMA was established to exercise general supervision and co-ordination on all matters relating to the environment. Standards Enforcement and Review Committee (SERC) in consultation with the relevant lead agencies is supposed to advise NEMA on how to establish criteria and procedures for the measurement of air quality and also to recommend to the authority: ambient air quality standards, occupational air quality standards, emission standards for various sources, criteria and guidelines for air pollution control for both mobile and stationary sources and any other air quality standards.

3.1.1.2. Environmental Management and Coordination (Fossil Fuel Emission Control) Regulations, 2006

These regulations stipulate that any internal combustion engine is subject to inspection and should, pass such tests as may be required to demonstrate that the internal combustion engine complies with any standards and requirements for the control of air pollution or contamination.

Under the Regulations, NEMA is empowered to approve any substance to be used as a fuel catalyst. Section 9 provides the details required and the procedure for application and approval of fuel catalyst. Section 12 states that the cost of clearing pollution through fuel emission shall be borne by the polluter.

The emission standards to be complied with by any internal combustion engine are set out in the First Schedule of the Regulations. The Petrol Powered Motor Vehicle Emission Standards vary with vehicle class and model year, the maximum allowed CO emission concentration is 6.5% for a vehicle of Gross weight between 6001 and 10,000 Ibs of models produced between 1975-1977. Section B of the schedule provides for the diesel powered motor vehicle emission standards which stipulate that no diesel-

powered vehicle shall emit visible emissions in excess of 20% opacity for 5 consecutive seconds or more when under applicable loading. The petrol and diesel standards are presented in appendix 8.9 and 8.10 of this report respectively.

The regulation stipulates the emission limits for both diesel and petrol powered vehicles. It further obliges petrol stations to dispense only fuels containing a specified catalyst as means of reducing vehicular emissions.

It stipulates the modalities of inspecting motor vehicles on the emission levels from the internal combustion engines. The regulation seems to advocate use of technology to guide regulation since it specifies the technology i.e. the catalyst to be used to achieve the emission limits.

3.1.1.3. Draft Air Quality Regulations

The NEMA through the SERC has coordinated formulation of the draft Air Quality Regulations which will repeal the fossil fuel control regulations currently in place. The regulations oblige facilities to submit emission measurements and also indicate their emission points. Under the regulation, NEMA may initiate measurements of emissions in case of complaints. These regulations are applicable to emissions from all internal combustion engines. The draft Regulations provide for the introduction of fuel catalysts. The Priority Air Pollutants (PAP) from the mobile sources include: Hydrocarbons (HCs), Volatile Organic Compounds (VOC), Sulphur dioxide (SO_x), Nitrogen Oxides (NO_x), Particulates Matter (PM) and Carbon Monoxide (CO). Regulation 26 states that the Authority in consultation with the Motor Vehicle Inspection Unit (MVIU) may at any time order the inspection of a vehicle releasing visible exhaust emissions.

These regulations stipulate the emission limits for various source categories depending on the facility size. They also highlight the priority air pollutants of concern emitted by these facilities for ease of monitoring and inspection. They stipulate the emission limits

for motor vehicles using different fuel types. These regulations also guide on options for reducing vehicular emissions.

They provide for designation of private vehicle testing garages to cater for the anticipated increased volume of vehicles to be tested.

They provide for biennial and annual vehicular exhaust emission measurements for private vehicles and for both public service vehicles and commercial vehicles.

3.1.1.4. The National Climate Change Action Plan (NCCAAP)

The plan identifies the need for vehicle emission control technologies such as catalytic converters. Since the combustion process is never perfect, some smaller amounts of more harmful emissions are produced in car engines. Catalytic converters are designed to reduce the harmful emissions of Carbon Monoxide (CO), Volatile Organic Compounds (VOCs) and Nitrogen Oxides (NO and NO_2).

Although the NCCAAP provides for the introduction of catalytic converters in vehicle exhaust systems to reduce emissions, there is no substantive law that makes it mandatory for vehicles (Heavy Commercial vehicles) to have the catalytic converters.
The plan also proposes other measures to reduce vehicle emissions, here-in are some of the proposed strategies:

a) Employ more effective traffic management technologies, especially traffic control lights to reduce vehicle travel time mainly in urban areas.
b) Enhance vehicle inspection regulations to include personal cars and also to enforce emission controls.
c) Formulate a regulatory and economic framework that will lead to reduction of old inefficient vehicles from the roads.
d) Transfer and deploy technologies for solar energy-driven small vehicles. Hybrid vehicles that use both solar and fossil fuel energy are good examples.

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

3.1.2. The Transport Sector

In addition to the discussion above on 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. The relevant policy, acts and regulation in the transport sector are discussed below.

3.1.2.1. Traffic Act, 2009; Chapter 403

Under the Act, all vehicles more than four (4) years old from the recorded date of manufacture should be subjected to inspection by the Motor Vehicle Inspection Unit (MVIU). The Act provides for inspection of motor vehicles and the existence of inspection centers. MVIU is charged with the responsibility of ensuring the provisions of the Traffic Act and subsidiary rules relating to Motor Vehicle examination and that all vehicle owners comply.

The transport sector is responsible for about 26% of global carbon emission and is projected to increase to 75% between 1997 and 2020 (U.S.E.P.A. 2002). Greenhouse gas emissions from motor vehicles present longer term problems potentially with severe health, environmental and economic consequences. Use of fuel efficient vehicles is important for stabilizing atmospheric concentration of pollutants.

During motor vehicle inspection, the tests checks and ascertain that vehicles meet road safety and environmental standards. The inspection certificate confirms that at the time of the test, without dismantling it, the vehicle met the minimum acceptable environmental and road safety standards required by law. The certificate is valid for a specified period of time; two years for private cars and one year for PSV and commercial vehicles.

The exhaust emission testing are conducted in accordance with standards set by KEBS (KS 1515:2000, KS 2060:2007, KS 1309-1:2010, KS 03-1099:1992).

3.1.2.2. Integrated National Transport Policy, 2009

Chapter fourteen (14) of the policy points out that, Kenya has not adequately incorporated environmental policies in transport infrastructure development, management and operations. The policy proposes the use of efficient and less polluting modes of transport and encourages non-transport interventions to mitigate the adverse environmental effects of transport. It also proposes domestication of international conventions on efficient and less polluting fuels, the policy further recommends regular inspection of motor vehicles to ensure control of noxious gaseous emissions and telecommuting as an alternative means of transport (in the long term) particularly within urban areas. Section 14 of the Policy proposes the use of low sulphur fuels. The policy also provides strategies of dealing with Public Service Vehicles as far as proper maintenance, air and noise pollution are concerned. The policy also emphasizes the need to adopt the use of lead free fuel. Lead was phased out in the year 2005 following the Dakar Declaration.

Lack of a clear decision as to which modes of transport and facilities the urban areas should encourage or provide has been identified as a result of lack of an urban transport policy. Development of an urban transport policy should aim at developing an integrated, balanced and environmentally sound urban transport system in which all

modes efficiently play their roles. It should encourage use of Bus Rapid Transit System (BRTs). Although there is a proposed Nairobi Metropolitan Region Bus Rapid Transit System and the development of a light rail for Nairobi there is need for an urban policy for all cities, towns and other urban centres in the long term.

The policy also identifies the need to incorporate Non-Motorized and Intermediate Means of Transport (NMIMT) into the road transport network, the national transport system and into the road transport policy so that they can effectively play a complementary role in the transportation of both passengers and freight. There is need for their recognition, development, funding and technical support from various government bodies, local authorities and the private sector.

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

The Act provides for the establishment of the Authority, whose functions are to spearhead the implementation of policies in the road transport sector. The functions of the Authority include registration, inspection and licensing of motor vehicles. Under the Act, the Cabinet Secretary for the Ministry of Transport and Infrastructure may, in consultation with the Board, make regulations (for the better) in relation to the provisions of this Act.

3.1.2.4. The National Transport and Safety Authority (Operation of Public Service Vehicles) Regulations, 2013

Under Section 8 of the regulations, the operator of licensed public service vehicles is required to inspect the vehicle every seven (7) days. The operator should inspect the vehicle for mechanical and other defects according to a check list drawn up by a qualified mechanic and take action to rectify the defects.

3.1.3. Standards and Specifications

3.1.3.1 Standards Act, 1974; Cap 496

The Standards Act Cap. 496 of the Laws of Kenya started its operations on 12th July 1974. The Act is meant to promote the standardization of the specification of commodities and to provide for the standardization of commodities and codes of practice; to establish a Kenya Bureau of Standards (KEBS), to define its functions and provide for its management and control. Some of the functions of the KEBS as established under section 3 of the Act include:

- to promote standardization in industry and commerce;
- to prepare, frame, modify or amend specifications and codes of practice;
- to encourage or undertake educational work in connection with standardization;
- to assist the Government or any local authority or other public body on matters of standards

The National Standards Council established under section 6 of the Act may by notice in the gazette declare any specification or code of practice prepared by the Bureau to be a Kenyan standard. Section 9 of the Act stipulates the procedures for Declaration of Kenya Standard.In line with the mandate provided for in the Act KEBS have put in place the following standards in relation to the subject matter.

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

This standard was found necessary to regulate the quality and condition of road vehicles for safety, environmental and economic reasons. Some of the pertinent standards provided within KS 1515:2000 on vehicular emissions include:

a) Under Clause 1.2.2 the Standard applied to inspection of motor vehicles as per the Traffic Act;

b) Under Clause 2, all road vehicles shall be subject to inspection immediately before importation;

c) Under Clause 2.5, the Age Limit of all motor vehicles allowed for importation is restricted to 8 years and the difference between the date of registration and the date of manufacture shall not exceed one year;

d) Under Clause 4 and Appendix A, the following environmental requirements to facilitate exhaust emissions testing are prescribed:

   i) Visual inspection of all vehicles to ensure that they do not emit dense blue or clearly visible black smoke unless they are very old e.g manufactured before 1960;

   ii) Standard Emissions Test subject to which the concentration of Carbon Monoxide (CO) shall not exceed 0.5 per cent volume and hydrocarbons (HC) concentrations shall not exceed 0.12 per cent volume (1200 ppm)

   iii) Noise Level Test where the noise from a vehicle shall not exceed 90 dB;

e) Under Clause 5 the tests and equipment necessary to facilitate inspection for tests such as: exhaust emission tests, diesel smoke concentration test, fuel economy test are prescribed;

f) Clause 5.2 further provides for an inspection schedule in a tabulated format and Clause 5.2.1 provides for 5 different types of inspection as initial, periodic, modification inspections as well as inspection of vehicles involved in traffic accidents and on-roads random inspection.

g) Tables 3 and 4 provides for the exhaust emission limits for petrol powered cars both at natural engine idle speed as well as at raised engine speed with the gearbox in neutral to determine the CO and HC emissions which for vehicles registered in different years;

h) A2 has further specifications for diesel powered vehicles;

i) A study conducted by Langat et al (2008) on vehicle exhaust emissions measurements at a motor vehicle inspection center in Nairobi revealed that most vehicle fail emission test as per KS 1515-2000 standards. 69.5% and 71.1% of

petrol and diesel vehicles failed the emissions test respectively. Although the existing standards require revision and updating to fit the Kenya context implementation of existing standards should be fundamental.

j)

(ii) KS 2060:2012 – Motor Gasoline Specifications

The Standard specifies that the maximum lead content should be 0.015g/L and maximum Sulphur level should be 0.15%. The minimum Research Octane Number, RON is put at 87 and Minimum Motor Octane Number (MON) is 77.

Adopted East Africa Standard for Motor Gasoline

KS EAS 158 (2012): Motor gasoline, unleaded motor spirit premium - Specification

The two type of Octane Rating specified by KEBS Standard will change in the new EAC Standard. In the new standard the minimum Research Octane Number, RON is 93 and the Minimum Motor Octane number, MON is specified as 83. The Maximum lead content is put at 0.013 g/L, the maximum percentage Sulphur Content allowed is 0.15% sulphur.

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

This Standard specifies the maximum requirement of fuel Sulphur content at 500 ppm. The minimum Cetane Index required is 48.

Adopted East Africa Standard for Automotive Diesel

KS EAS 177 (2012): Automotive diesel – Specification - The minimum Cetane number in this standard is put at 51.0 and the Minimum Cetane index is at 48.0. The maximum allowed Sulphur content is 50mg/kg.

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

The standard, 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. Many vehicles in Kenya roads do not comply with the standards set.

3.1.4. The Energy Sector

3.1.3.1. Energy Act No.12 of 2006

The Energy Act, 2006 is an act of Parliament to amend and consolidate the law relating to energy, to provide for the establishment, powers and functions of the Energy Regulatory Commission and the Rural Electrification Authority. Energy Regulatory Commission (ERC) was established with responsibility for economic and technical regulation of electric power, renewable energy and downstream petroleum sub-sectors. One of the functions of ERC is to formulate, enforce and review environmental, health, safety and quality standards for the energy sector, in coordination with other statutory authorities. Other functions of ERC as stipulated in section 5 of the Act include:

(a) To issue, renew, modify, suspend or revoke licenses and permits for all undertakings and activities in the energy sector
(b) To make proposals to the Minister, of regulations which may be necessary or expedient for the regulation of the energy sector
(c) To enforce and review regulations, codes and standards for the energy sector
(d) Make and enforce directions to ensure compliance with conditions of licenses or permits issued under the Energy Act.

As per section 6 (c) of the Act, ERC has powers to formulate, enforce and review environmental, health, safety and quality standards for the energy sector, in coordination with other statutory authorities like NEMA and KEBS.

Under section 95 of the Energy Act; Petroleum imported or produced locally for use in Kenya, petroleum products, equipment, facilities and installations should conform to

the relevant Kenya Standard: Provided that where no such standard exists, the relevant international standards approved by the KEBs shall apply.

A person who offers for sale in Kenya or transports or stores petroleum meant for use in Kenya should ensure that the specifications of such petroleum is in accordance with standards set / approved by Kenya Bureau of Standards or those approved by ERC.

Section 102 of the Act empowers the Cabinet Secretary for Energy and Petroleum on the recommendation of the Commission, to make regulations:

- Providing for environmental, health and safety standards associated with the handling, storage and use of petroleum.
- In consultation with KEBS, prescribing apparatus for testing petroleum, the tests to be applied and the manner in which tests are to be made;
- In consultation with KEBS, appointing inspectors and agents for the testing and examination of petroleum and prescribing their powers and duties;
- Determining the retail prices of petroleum and petroleum products:

3.1.3.2. Sessional Paper No. 4 On Energy

In the Sessional Paper, the main challenges facing energy conservation and efficiency have been identified as high cost of introducing efficient and cost effective technologies, lack of awareness on opportunities offered, and inadequate fiscal incentives. Other opportunities include inappropriate and limited credit and financing mechanisms, lack of standards and codes of practice and regulatory mechanisms for their enforcement and inadequate capacity to promote and monitor penetration.

The paper indicates that the government will continue to pursue the following policies to enhance efficiency in motor fuels and to raise revenue.

a) **Taxation**: The government will continue to use taxation to mitigate demand and choke-off wasteful consumption of motor fuels, particularly petrol.

b) **Fuel Economy**: Government will develop and enforce standards for fuel efficiency of motor vehicle engines and also continue to enforce speed limits in order to achieve savings in petroleum fuels, in addition to reducing road accidents throughout the country.

c) **Awareness on opportunities to conserve fuel:** Measures will continue to be instituted aimed at raising awareness on the various methods of conserving fuel by adopting good driving and maintenance practices.

d) **Alternative form of transport:** Where appropriate, other transportation options will be encouraged such as mass transportation of passengers and cargo to encourage economies of scale and the attendant fuel efficiency.

3.1.3.3. Draft National Energy and Petroleum Policy

The overall objective of the energy policy is to ensure affordable, sustainable and reliable supply to meet national and county development needs, while protecting and conserving the environment. Factors of importance and urgency for energy efficiency and conservation are highlighted as: i) high energy prices, ii) insecurity of supply, iii) adverse environmental and health impacts and iv) depletion of energy resources.

The policy points out that, there is increasing concern about spiraling degradation of the environment as exemplified by increased local air pollution and acid precipitation from ever growing fossil fuel combustion. The Draft Policy document has identified various challenges in the energy sector. Challenges in institutional arrangements include governance issues, lack of a research institute, funding constraints and inadequate human resource capacity.

Operational challenges including lack of synergy and overlap of the mandates of the various institutions. This leads to duplication of roles and suboptimal utilisation of available resources.

In the Mid and Downstream Petroleum Markets, existing challenges include the following:

i) Inadequate capacity to store and evacuate petroleum products
ii) High initial cost of acquiring the necessary infrastructure
iii) Inadequate storage infrastructure and strategic reserves
iv) High petroleum fuel prices
v) Lack of proper planning and coordination of petroleum infrastructure

The draft policy document has proposed various strategies and activities to deal with energy inefficiency in the transport sector. Some of the agenda for action-implementation proposed in Section 2.2.15 of the draft policy are:

I. Short Term 2012 – 2016

(a) Disseminate energy efficiency and conservation information to consumers.
(b) Develop standards and codes of practice on cost-effective, efficient energy use.
(c) Undertake necessary amendments to relevant tax legislation to provide for appropriate fiscal and other incentives to exploit energy efficiency and conservation opportunities.

II. Medium Term 2012 - 2022

(a) Develop and enforce standards for fuel economy through speed limits, efficiency of motor vehicle engines, adopting good driving and maintenance practices.
(b) Promote mass transportation of passengers and cargo to encourage economies of scale and the attendant fuel efficiency.
(c) Promote energy efficient means of transport of fuels, taking advantage of bulk transport where appropriate.

III. Long Term 2012 - 2030

Promote the introduction of new and efficient technologies such as hybrid, Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG), fuel cell and electric vehicles through demonstration, research and training.

3.1.5. Tax Provisions

The duty payable on the importation of a motor vehicle is as follows:

1. **Import Duty:** 25% of the CIF value of the vehicle (subject to the provisions of the first schedule of the customs and Excise Act - Chapter 472 of the laws of Kenya).
2. **Excise Duty**: 20% of the (CIF value + Import Duty) also (subject to the provisions of the First Schedule of the Customs and Excise Act - Chapter 472 of the Laws of Kenya)
3. **VAT:** 16% of the (CIF value + Import Duty + Excise Duty) which is (subject to the VAT Act 2013)
4. **Import Declaration Fee (IDF):** 2.25% of the CIF value or Ksh. 5,000, whichever is higher, is payable.

3.1.4.1. VAT Act 2013

The VAT Act 2013 came into operation on 2nd September, 2013. The Act has only two rates of tax namely:-

- 16% for all goods and services not listed in the exempt and Zero rated schedules.
- 0% for goods and services listed in the second schedule.

The VAT Act 2013 has two schedules:-First Schedule that lists all the exempt goods and services and the second schedule that lists all the zero rated goods and services. All goods and services not listed in the 1st and 2nd Schedules are taxable at the rate of 16%, suppliers of zero rated goods and Services qualify for input tax deduction. Motor Vehicles and Motor Fuels attract VAT.

3.1.4.2. Customs and Excise Act

Excise taxes in Kenya are imposed under the Customs and Excise Act (Chap 472). The administration of excise taxes is the responsibility of the Customs and Excise Department of the Kenya Revenue Authority. The first schedule of the Customs and Excise Act provides information on import duties. The second schedule provides information on suspended duties and the third schedule on good for exemption from import duty. The current import duty of vehicles is calculated on the cost of the vehicle (CIF), cheaper older vehicles attract lesser tax compared to newer vehicles.

3.1.4.3. The East African Community Customs Management Act (EACCMA) 2004

The EACCMA, 2004 lays out the Exemptions Regime in part b of the 5th schedule of the EACCMA, 2004. The Act primarily grants exemptions to persons who are returning residents from other jurisdictions subject to an elaborate plethora of provisions in the Schedule which they must satisfy to qualify for the exemptions.

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. For instance the standard on second hand vehicle importation (KS 1515:2000) is restrictive on the age of vehicle imported but does not address the need for fuel catalytic converters that will assist minimize air pollution of old vehicles already in the Kenyan market.

Kenya's development in the transport sector in the last 3 years is laudable 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 in Nairobi city. But documentation remains scanty on legislative action to actively combat any GHG emissions. There is need to incorporate this proposal in an urban transport policy.

Various instruments have been used worldwide to enhance fuel efficiency. This can be categorized in the form of regulatory policies, economic instruments, traffic control measures, information and technology. Below are some of the best practices in selected countries in Africa, E.U and the U.S.A.

3.2.1. South Africa

In July 2008 South Africa introduced a labeling system for all new passenger cars offered for sale in the country. All car dealers in South Africa have to display stickers on the windscreens of new cars, informing prospective buyers on Vehicle fuel efficiency as measured in terms of the EU 'Combined Cycle' and the corresponding amount of carbon dioxide emitted. A database of new vehicle fuel economy and CO_2 emission figures is maintained on the National Association of Vehicles Manufacturers of South Africa (NAAMSA) web site.

3.2.2. Mauritius

Mauritius imposes three taxes on vehicle ownership (all related to engine size) as measured by cylinder capacity in cubic centimeters (cc). There is a one-off excise duty on the car price of 55 percent if the engine capacity is less than 1,600 cc or 100 percent if the engine capacity is greater than 1,600 cc.

The country has also an excise duty based on CO_2 emission for vehicles. As per section 5 of the country's Excise (Amendment) Act 2011 a **CO_2** levy shall be chargeable, or a **CO_2 rebate** shall be granted, as the case may be, on the motor vehicles. The levy/rebate complements existing fees for cars, and is calculated with the following formula:

$$A = R \times (C - T)$$

Where:

A is the amount of the CO_2 levy or CO_2 rebate;

R is the appropriate rate of the CO_2 levy, or the appropriate CO_2 rebate per gram per kilometer (km) depending on the categorization of the vehicle according to the law;

C is the CO_2 gram per km of the motor car, rounded to the nearest whole number;

T is the CO_2 threshold currently placed at 158 grams per km.

The country has also a one-off registration fee for imported vehicles of between Rs 12,500 and Rs 150,000 (US$416–5,000) depending on engine size. Registration fees are paid (at lower rates, depending on vintage) if vehicles are subsequently sold. And there is an annual road tax of between Rs 3,500 and Rs 13,000, again depending on engine size. The country's 2011 Excise Act requires every vehicle importer to provide a CO_2 emission certificate issued by the manufacturer of the motor car; in the case of a second-hand motor car, an inspection certificate is required.

3.2.3. Egypt

Egypt has high government tariffs on new completed imported cars which have led to many foreign manufacturers assembling their vehicles in Egypt. On the other hand all imported **Second Hand** vehicles must be equipped with **a catalytic converter**. The imported second-hand vehicles must be less than 3 years old.

3.2.4. United States of America (U.S.A)

U.S.A has comprehensive standards and laws on emissions from combustion engines. The country also has comprehensive measures to reduce emissions from heavy duty diesel trucks. In Kenya these trucks contribute a substantial amount of GHG's into the environment. The U.S.A has an Energy Policy and Conservation Act (EPCA) signed into law in 1975. The Act created the CAFÉ standards which have been in place since 1978.

3.2.5. European Union (EU)

European Union has developed various policies and measures on vehicle fuel efficiency. Apart from EU policies, EU partner countries have also developed laws and measures to improve vehicle fuel efficiency in their Nations. Table 3.1 shows the Regulatory Policies, Traffic Control Measures and Vehicle Information Dissemination Methods in the European Union and U.S.A.

Table 3-1: Regulatory Policies, Traffic Control Measures and Vehicle Information Dissemination Methods in the European Union and the U.S.

		European Union	United States
REGULATORY POLICIES	National Standards	On April 23, 2009, the European Parliament and the Council approved regulations setting a target of 130 g/km (5.6 l/100km or 42 mpg) for the average emissions of new cars to be phased-in by 2015. A longer-term target of 95 g/km (4.1 l/100km or 57.6 mpg) has been established for 2020.	The U.S. enacted the Energy Policy and Conservation Act (EPCA) which created the CAFE standards, this act was signed into law in 1975. Two sets of standards have been established: those for passenger cars and for light trucks.
	Import restrictions	New Vehicles brought into the EU must comply with the EU's type-approval directive (EU Council Directive 92/53). Vehicles with EU type-approval can be marketed anywhere in the Community.	There are no import restrictions in the U.S. Any vehicle that meets the emission standards in place for each year may be sold in the U.S. New vehicles are subject to certain rules as specified by the U.S. Clean Air Act in terms of emission standards and the EPCA in terms of fuel economy. Second-hand vehicles must follow certain procedures to make sure that they meet the current emissions and safety standards.
	Technology mandates/targets	Car manufacturers in Europe are pursuing various technology options to meet the CO_2 95 g/km target for 2020	There are no technology mandates as such in the U.S. The standards in place are performance-based standards.
FISCAL MEASURES AND ECONOMIC INSTRUMENTS	Fee-bate	France enacted a bonus-malus system, which is essentially a feebate system for cars. More efficient cars receive a bonus when purchased, while inefficient cars receive a penalty when purchased.	1978 the U.S. imposed a tax called the Gas Guzzler Tax. The gas guzzler tax is an excise tax enacted in on the sale of automobiles within "model types' whose fuel economy fails to meet certain fuel economy requirements. The tax is imposed on manufacturers. This law applies a tax to vehicles that achieve less than a specified fuel economy rating, i.e. 22.5 mpg combined city and highway rating. This tax goes from $1,000 for a vehicle that achieves at least 21.5 mpg up to $7,000 for a vehicle that gets 12.5 mpg.
	Buy-back	Some of the EU countries initiated programs to get older cars off the road in return for the consumer buying a more efficient vehicle. An example is the scrappage program of France, which was introduced on January 19, 2009. The old car would need to be older than 10 years and the new car would need to	In 2009 the US government signed into law the provision of rebates to prospective car purchasers toward the purchase of new, fuel-efficient vehicles, provided the trade-in vehicles were scrapped. The “cash for clunkers” (also known as the Car Allowance Rebate System - CARS)

		meet a particular CO_2 emission standard. It starts with €1000 for a car which emits a maximum of 160 g/km.	law.
	Penalties	The regulation on vehicle CO_2 sets a penalty mechanism based on excess emission payments. If a manufacturer fails to meet its target in a given calendar year, it will be required to pay an excess emissions premium.	
	Registration fees	Registration fees are handled by the countries in the EU, although a common EU registration program was introduced. The common EU format was introduced by Council Regulation (EC) No 2411/98 of 3 November 1998 and entered into force on the 11 November 1998.	
	R&D	The Green Car Initiative, a part of the European economic recovery plan, aims to allocate €5 billion (US$6.7 billion) through a Public Private Partnership to bolster innovation in the automotive sector and sustain its focus on environmental progress.	In January 2003, the U.S. government announced a 5-year, $1.2 billion Hydrogen Fuel Initiative to perform research, development, and demonstration (R&D) for developing hydrogen fuel cells for use as a substitute for gasoline engines. In addition, the US EPA is making grant funds available for research to develop new cutting-edge engine technologies.
TRAFFIC CONTROL MEASURES	Priority lanes	Road policies to encourage low emission vehicles are set at the national level within the EU.	Various states in the U.S. have priority lanes for access by hybrid vehicles and High Occupancy Vehicles. For example the Clean Pass program allow eligible low-emission, energy-efficient vehicles to use the 40-mile New York Long Island Expressway/High Occupancy Vehicle (LIE/HOV) lanes, regardless of the number of occupants in the vehicle.
	Parking	Sweden has a significant program on clean vehicles and as part of that provides free parking for electric vehicles and other clean vehicles	Some states give priority parking to certain vehicles, such as California, where there are electric vehicle (EV) charging stations where only EVs can park.
	Road pricing	In central London (United Kingdom), low-emission vehicles – in particular HEVs - are exempt from the £8 daily London congestion charge. Due to their low levels of regulated emissions. The greenest cars are eligible to 100% discount under the current system.	There are High Occupancy Toll (HOT) lanes in California where the driver pays for the privilege of driving in a HOV lane.

INFORMATION	Labeling	Directive 1999/94/EC stipulates that a fuel economy label must be attached to the windscreen of all new passenger cars at the point of sale.	There has been a fuel economy labeling program in the U.S. since the CAFE standards were put in place in 1978. It was designed and is administered by the EPA.
	Public info	EU Directive 1999/94/EC (as amended by 2003/73/EC) requires new car fuel consumption and CO_2 emissions data to be made freely available to consumers. Car dealers are required to have a label showing the fuel consumption and CO_2 emissions of each different model on display.	Auto dealers are required to have copies of the gas mileage guide available on the showroom floor. This is required by federal law.
	Industry reporting		Besides the USEPA website, very specific data on vehicle type, weight, transmission type, etc. are available from publications such as Ward's Auto Reports and Automotive News. The US EPA also publishes the Fuel Economy Trends Report. This document follows the trends in fuel economy over the past year and does a number of analyses based on the fuel economy data.

3.3. Challenges in the Implementation of Existing Legal and Regulatory Framework

There exist several challenges in the existing legal framework in the transport industry on implementation of vehicle emission reduction strategies among them, the inadequacy of resources to implement policy, overlapping of tasks between the various authorities and an inadequate motor vehicle inspection system.

There is 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. There is widespread apathy at the grassroots on environmental degradation and its effects. The public should thus be educated on the effects of air pollution on human health, climate change and on means of reducing air pollution.

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, and KEBS 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 at the policy level by NTSA.

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. For instance MVIU has 17 motor-vehicle testing centers nationally and has inadequate emission testing equipment and facilities to undertake tests on all vehicles used in the country. Although the unit should license environmental inspectors they also lack adequate staff and offices across the country. The inadequacy of a sufficient number of staff to conduct inspections perceptibly influences the tracking and recording of the quality of the Kenyan vehicle fleet as well as the resulting emissions.

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 licensed environmental inspectors) may be 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. The Registrar of Motor Vehicles - a department of KRA has been the official public repository of vehicle registration data since 2005. After the enactment of the National Transport and Safety Authority (NTSA) Act, KRA transferred registration of vehicles to NTSA, However KRA Continue to offer support services.

3.3.4. Inspection of Motor Vehicles

Currently private cars, PSV and commercial vehicles are not adequately subjected to the mandatory inspection as required by Law. As per the Traffic Act, mandatory inspection of vehicles should be done after every two years for private cars and after

a year for PSV and commercial vehicles. Lack of adequate inspection garages and personnel for the MVIU has made it impossible to inspect all vehicles as required.

3.3.5. Lack of Transport 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 then acts as constraints to optimal utilization of the transport systems. It is therefore necessary to ensure inter-modal connectivity among the various transport modes as envisioned in Vision 2030. The Integrated National Transport Policy envisages intermodal Integration by proposing the Bus Rapid Transit system (BRT) and the Light Rail System (LRS) in Nairobi as stipulated in Vision 2030.

Railway transportation should be developed for intermodal Linkages to Airports, Ports and Road Transport to strengthening regional and inter-urban infrastructure. Efficiency in the transport network will reduce fuel emissions. The Standard Gauge Railway (SGR) will be essential in linking up the commuter rails and the national ports. 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 bears several gaps including:

3.4.1. Inadequate 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 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 in 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, there is need for an urban policy for all cities, towns and other urban centers in the long term.

Devolution of roads should extend beyond the capital, its precincts and the highways. Ultimately, the transport policy must compliment the fourth schedule of the constitution which delineates the role of county governments in the development of road networks in the country. As per the County Governments Act (No. 17 of 2012) and Urban Areas and Cities Act (No. 13 of 2011) county governments should develop cities and urban areas plans. Urban Transport Plan should form part of Urban Areas and Cities Plan.

The National 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[2]) should be formed.

3.4.2. Policy Frameworks on Bio-fuel Development

The push towards cleaner energy sources and price volatility of petroleum fuels 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

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

leading the way[3]. Needless to say, Vision 2030 has mandated the Government to update Kenya's renewable energy database as well as develop its bio-fuel value chain for bio-ethanol production and feedstock for bio-diesel development in the next four financial years.

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.

Sessional Paper No. 4 of 2004 on Energy seeks to encourage wider adoption of renewable energy technologies, thereby enhancing their role in the country's energy supply matrix. The Ministry of Energy and Petroleum, developed a strategy on the bio-diesel industry in Kenya. The strategy paper identifies the need to have ERC develop necessary regulations for the bio-fuel industry in consultation with key stakeholders.

3.4.3. Inadequate Standards and Specification

Kenya lacks adequate standards and specifications for vehicles imported into the country. Second hand Vehicles imported should comply with the standards set by KEBS, i.e., KS 1515:2000, discussed in section 3.1.2.5 of this report. There are no standards for new vehicles imported or assembled in the country. The existing standard is uniform for light and heavy duty vehicles which should generally have different standards as is the case in the United States of America where vehicles are inspected in accordance with regulation set by the US Environment Protection Agency as per the Clean Air Act.

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

The vehicle emission inspection standards to be complied with include those set out in Environmental Management and Coordination (Fossil Fuel Emission Control) Regulations, 2006 discussed in section 3.1.1.2. The requirement vary with vehicle model and date manufactured. 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 adequately 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. The standards should vary for different vehicle classes taking into account the global standards as well as benchmarking with international best practices.

3.4.4. Lack of Reward for 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 instance, Kenya Revenue Authority has a duty calculator which it relies on to compute 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 a more attractive taxation regime should be adopted. If this was to be done, then newer vehicles would be imported in greater numbers [as opposed to the current scenario where older vehicles are imported because the duty amounts levied on them are lower] and the emissions would be reduced in addition to improving fuel economy.

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 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 to determine the amount of duty payable. Therefore, older cars and those with hazardous emissions will be imported *en masse* thereby defeating the objective of reducing emissions.

In Sweden, the prevailing principle since the 1920's has been to levy energy and CO_2 taxes on fossil fuels when used as motor fuels. The CO_2 tax is levied on fuels containing fossil carbon, and the Swedish CO_2 tax rates have been significantly increased over the years, with the purpose of achieving cost-effective emission reductions. The Tax works well in combination with other instruments of climate and energy policy, such as green certificates, subsidies to renewable energy and regulations that have been introduced after/before the tax.

3.4.5. Lack of Policies 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, products that are most hazardous to the environment would be the most highly taxed while least hazardous ones would be subsidized, thereby incentivizing the persons that transact

in these products as well as the consumers of this products to embrace less hazardous ones. In Sweden, Government (for instance) has introduced high-ratio blends of renewable products into gasoline and diesel (E85, ED95 and biodiesel – 100% Fatty Acid Methyl Ester [FAME]) which are subject to a full tax exemption. This is done under the country's integrated climate and energy policy. In addition, pumping stations which sell more than 1 000 cubic metres per year are required (as part of government policy) to offer a renewable fuel as an option to its clients.

3.5. Study Findings

a) The regulations on vehicular emissions do not stipulate a standard fuel economy for various vehicle models to be imported into the country.

b) The exercise duty charged on imported vehicles is based on the age of the vehicle but not on the fuel economy.

c) There are no clear incentives that promote importation of fuel efficient vehicles.

d) The vehicles are inspected visually for mechanical soundness but exhaust emissions not measured

e) The draft air quality regulations recommend annual vehicular exhaust emission measurements.

f) There is inadequate analytical capacity both technical and personnel to carry out vehicular exhaust emissions.

g) There are stricter standards of sulphur in both diesel and petrol but there are challenges of fuel adulteration,

h) There is a strict fuel marking and monitoring program implemented by ERC, KRA and KEBS. Offenders face stiff penalties as provided in the Kenyan laws.

i) There is harmonized EAS 158 and 177 for petrol and diesel for the East African Community

j) There are plans to decongest the urban roads through improved urban infrastructure and establishment of by-passes

3.6. Conclusion and Recommendation

The report has listed the relevant areas addressed in legislative provisions key in reduction of vehicle emissions in Kenya in various contexts including: environmental, energy and transport. In each of these 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 in 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 Table 3-2.

Table 3-2 Recommendations related to regulations governing the Transport sector Recommendations, responsibility and time frame

	Legal Provision	Gaps	Recommendation	Responsible organization	Time-span
1.	There is an 8 year age limit on the importation of vehicles. As per *KS 1515:2000 Code of practice for inspection of road Vehicles developed* by KEBs as per the Standards Act.	Due to the EAC Integration, the 8 year age limit on the importation of vehicles is not fully adhered to. Uganda and Rwanda have no limit whereas Tanzania just adopted the 8 year rule The wear and tear of some classes of vehicles especially PSV's is not environmentally sustainable after continuous use.	• Work together with EAC Member countries to harmonize the age limit of vehicles • Limit the importation by further raising taxes on imported cars while encouraging local assembly by international manufacturers. • Gradually reduce the age limit from 8 to 4 over an appropriate time frame e.g. Year 2020 in a harmonized approach with the EAC Partners Ensure that all vehicle that exceed the 4 year manufacturing date have catalytic converters • Work with EAC countries to introduce vehicle scrapping programs and compulsory repair & maintenance especially for PSVs • Develop and strictly enforce emissions vehicle standards and specifications (for PSV and private cars)	• KEBS • NEMA •Ministry of Trade and Industrialization, • KRA • EAC	48 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. • Enhance the capacity of the MVIU both within and out of urban areas to effectively carry out inspections.	• Ministry of Transport and Infrastructure • NEMA • MVIU • Kenya Police	60 months
3.	Regulations are present and considerable enforcement against overloading commercial vehicles.	The present policy framework available is not enough to regulate emissions and Kenyan driving habits	• Mass dissemination to drivers can be encouraged to modify behaviours that unnecessarily increase consumption and thus emissions by 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 poor driving habits	Ministry of Transport and Infrastructure and the Police Traffic Department, NTSA.	6 months

4.	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
5.	There has been the construction of a Bus Raid Transit (BRT) System in Nairobi, and construction is ongoing in other major towns 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)	Ministry of Transport and Infrastructure and NTSA	48 months
6.	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 gCO_2/km) and introduce rebate system to reward less polluting vehicles	Ministry of Transport and Infrastructure The National Treasury	12 months
7.	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 CO_2 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.	Ministry of Transport and Infrastructure	12 Months

8.	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 of less polluting vehicle fuel technologies. This 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 tires to replace the two tire system. However, this should be approached warily with a particular caution as to the effect on the roads	Ministry of Transport and Infrastructure	24 months
9.	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 and Infrastructure	12 months

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 worldwide about 800,000 people die prematurely each year 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 annually (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 and 2011). 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. 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). Past surveys in Nairobi have

shown black carbons (BC) concentrations to be 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). An earlier study in Nairobi reported high levels of $PM_{2.5}$ and BC concentrations measured in the Central Business District and along Thika Road around Githurai roundabout (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 correlate specific vehicle emissions to public health.

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.

4.1.1. 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 of 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 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 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 due to 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 – 2014*

Table 4-3 captures the emissions of NOx based on the vehicle fleet population and the Vehicle Kilometres 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 were insignificant.

Table 4-3: Estimation of vehicle emissions NO_x

Estimation of NO_x 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 ailments associated with vehicle emissions but this depends on the level of the health facility. For instance, it was established 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 death 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	Ksh.	US$.
No. of patients seen with non-infectious respiratory illnesses/year*	6,235,470	68,590
Rate -approximate cost of treating a per patient per year **	16,800	185
Economic Loss Per Year (KShs)	104,755,887,600	1,153,314,764
Economic Loss Per Year (With additional 10% for unreported and asymptomatic cases)	115,231,476,360	1,267,546,239

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:

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

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:

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

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.

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

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, Odhiambo *et al.*, (2010)".

** 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 by 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

Then YLD is computed 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 greater than 90% among those less than 5 and greater than 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 older than 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 to 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 infectious diseases 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 reduce it by 50% 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). Before adopting these set of policies, it is important 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 the 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; 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 determine 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 CO_2 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 CO_2 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: *Consultants' 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 of 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 the proportion of used vehicles in the inventory.

Fuel efficiency costs and benefits

Table 5-5 indicates the estimates of costs based on total fuel consumption and 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 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

Note: 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 30 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 diesel engine registered constitutes 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 an 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 21 billion. In summary, the overall total expenditure is estimated at **Kshs. 55 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, 2014) and the Intercontinental Carbon Exchange (ICE, 2014). This exchange is applicable in 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 CO_2 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 registered vehicles in 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 (2012) 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 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 CO_2 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 registered motorcycles in 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 (Chapter 4), 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. Equation 5.1 captures the application of the discount rate (Groenendjik and Dopheide, 2003).

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

where;

I = Discount rate in decimals (0.1 for rate of 10%),

t = 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 Equation 5-2 (Groenendjik and Dopheide, 2003).

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

Where;

B_t = Periodic benefit,

C_t = Periodic cost, and

Σ = Summation sign.

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

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

The Net Benefit Investment Ratio (N/K):

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

Where;

N_t = Incremental net benefit in each year after the stream has turned positive,

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

n = Number of years (hence t=1,2,…,n) and

r = 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 manufacturing 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 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

Note: *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 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, 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

Table 6-1 below presents recommendations were made at the conclusion of the

Table 6-1: Study Recommendations

No.	Areas for Intervention	Gaps	Recommendation	Responsible organization	Time-span
1.	Motor Vehicle Inspection	• Mandatory vehicle inspection is not fully implemented. • There are only 17 vehicle inspection units which cannot adequately handle all vehicles in the country.	The Motor Vehicle Inspection Unit should develop capacity to: • Conduct regular inspection on vehicle safety, roadworthiness and exhaust emissions for all vehicles. • The Government through the Ministry of Transport and Infrastructure should increase capacity of the MVIU or license credible garages to provide the inspection services to all vehicles and motorcycles.	• Ministry of Transport and Infrastructure • NEMA • MVIU • Kenya Police	48 Months
2.	Infrastructure and transport planning	• Lack of Mass Transit (Bus/Train) and inadequate utilisation of Non-Motorized Transport modes • Centralized Management of roads	• The Ministry of Transport and Infrastructure should establish a framework for provision of mass transit (Bus/Train) to enhance a shift from private car dominance and provide for Non-Motorized Transport modes i.e. bicycles lanes, special lanes for carpooling and pedestrian lanes. • Government should encourage the 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. • Development of an urban transport policy and establish a Metropolitan Transport Authority (MTA) • Devolution of roads should extend beyond the capital, its precincts and the highways	• Ministry of Transport and Infrastructure • Kenya National Highways Authority (KENHA)	48 Months

3.	Health surveillance	• Lack of data on urban air quality • Lack of information on economic burden of vehicle emission related illnesses.	Ministry of Health and Ministry of Environment should establish a framework to: • Conduct continuous 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.	• Ministry of Health • Ministry of Environment and Mineral Resources • NEMA	24 Months
4.	Vehicle and fuel Standards	• Inadequate implementation of existing standards	National Transport and safety Authority should establish a framework to: • Phase out motorcycles with two stroke engines on account of high pollution and fuel consumption. • Implement all relevant existing standards.	• NTSA	12 Months
5.	Fiscal Instruments	• There is currently no fiscal policy that encourages car buyers to prefer more efficient, lower emission vehicles.	• The government through treasury should develop and introduce a feebate program and offer subsidies 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 National Tresury • ERC • KEBS • NEMA	24 Months
6.	Vehicle Labelling Scheme	• It is currently not mandatory for vehicle dealers to display information on fuel efficiency of vehicles they sale.	• The government through KEBs should introduce a vehicle labelling scheme which makes it mandatory for vehicle dealers to display information on fuel efficiency	• KEBS • NEMA	12 Months
7.	Vehicle Loading	• The present policy framework available is not enough to regulate emissions due to overloading of vehicles and Kenyan driving habits	• Education for drivers should be encouraged to help change behaviours that unnecessarily increase fuel consumption and thus emissions. • Mass dissemination of education through the various media to the Kenyan population on the effects on emission as a result of poor driving habits. • The adoption of anti-idling systems by all truck assembling companies to all vehicles manufactured after 2015. • An adoption of the wide base tires to replace the two tire system. However, this should be approached warily with a particular caution as to the effect on the roads	• Ministry of Transport and Infrastructure and the Police Traffic Department.	12 months 36 Months

8.	Introduction of Low polluting fuel blends	• Unleaded fuel still contains GHG emissions thus the need to use alternative fuel. • Kenya Lack a Biofuel Policy.	• Development of Biofuel Policy • Adoption of new fuel blends that contain high ratio blending with diesel and petrol. • The government should invest more in research on less polluting vehicle fuel technologies. This 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 Energy and Petroleum • Ministry of Industrialization and the Ministry of higher education	48 Months
9.	Introduction of buy backs	• 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
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 and Infrastructure	12 Months
11.	Inter-Sectorial Coordination	• Lack of Coordination among Key institutions in the transport sector.	• Organize workshops and meetings for key players in the transport sector.	• NTSA • Ministry of Transport and Infrastructure	Immediate

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8 APPENDICES

APPENDIX 8.1: GFEI Supervisory Committee Members

Name	Organization
Peter Kaigwara	ERC –EHS –Chair/Project Coordination/Implementation
Peter Watoro	ERC–EHS –Ass. Chair/Project Coordination/Implementation
Jane Akumu	Programme Officer, Transport Unit, UNEP
Esther Wairimu	Ministry of Transport and Infrastructure
Wanjiku Manyara	Petroleum Institute of East Africa
Mathias Muindi	Petroleum Institute of East Africa
Zechariah Karenge	General Motors East Africa
Pascal Vusa	Kenya Bureau of Standards
Joel Opere	Motor Vehicle Inspection Unit, NTSA
Peter Odhengo	National Treasury
Dr. John Mutua	ERC – Economic Regulation
Kimani Muhoro	ERC – Legal
Ezra Terer	ERC – Petroleum

Support Staff

Name	Function/Department
Silas Sanga	ERC – EHS/Project Implementation
Laura Wanyika	ERC – Communications and Public Affairs/Project Implementation

APPENDIX 8.2: Team of Consultants

Professional staff

Name	Position
Eng. Dr. Ayub Gitau	Team Leader
Prof. James Nyang'aya	Mechanical Engineer/Automotive studies
Dr. Eric Aligula	Economist
Dr. N Owuor	Statistician
Dr. L. N. Muhia	Medical Practitioner
Tirimba Machogu	Lawyer

Support staff

Name	Position
Rita Muriuki	Project Officer / Administration
Peter K. Kangethe	Project Assistant and Environmentalist
Robert Mathenge	Project Assistant and data entry

APPENDIX 8.3: Stakeholders Consulted During the Study

Contact Person	Organization
Francis Meja	Motor Vehicles Registration Unit, Kenya Revenue Authority
Zechariah Karenge	General Motors East Africa
Pascal Vusa	Kenya Bureau of Standards
Joel Opere	Motor Vehicle Inspection Unit, NTSA
Mutung'u Mwai	National Environment Management Authority
Esther Wairimu	Ministry of Transport and Infrastructure
Frances Cattermole	Kenya Motor Industries Association
Mathias Muindi	Petroleum Institute of East Africa
Karai Musee	Insurance Regulatory Authority (IRA)
Mary Wahome	Association of Kenya Insurers (AKI)

APPENDIX 8.4: Definitions of Relevant Terminologies

A-1 Test Cycles

How is the fuel consumption test conducted[4]?

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°C to 30°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

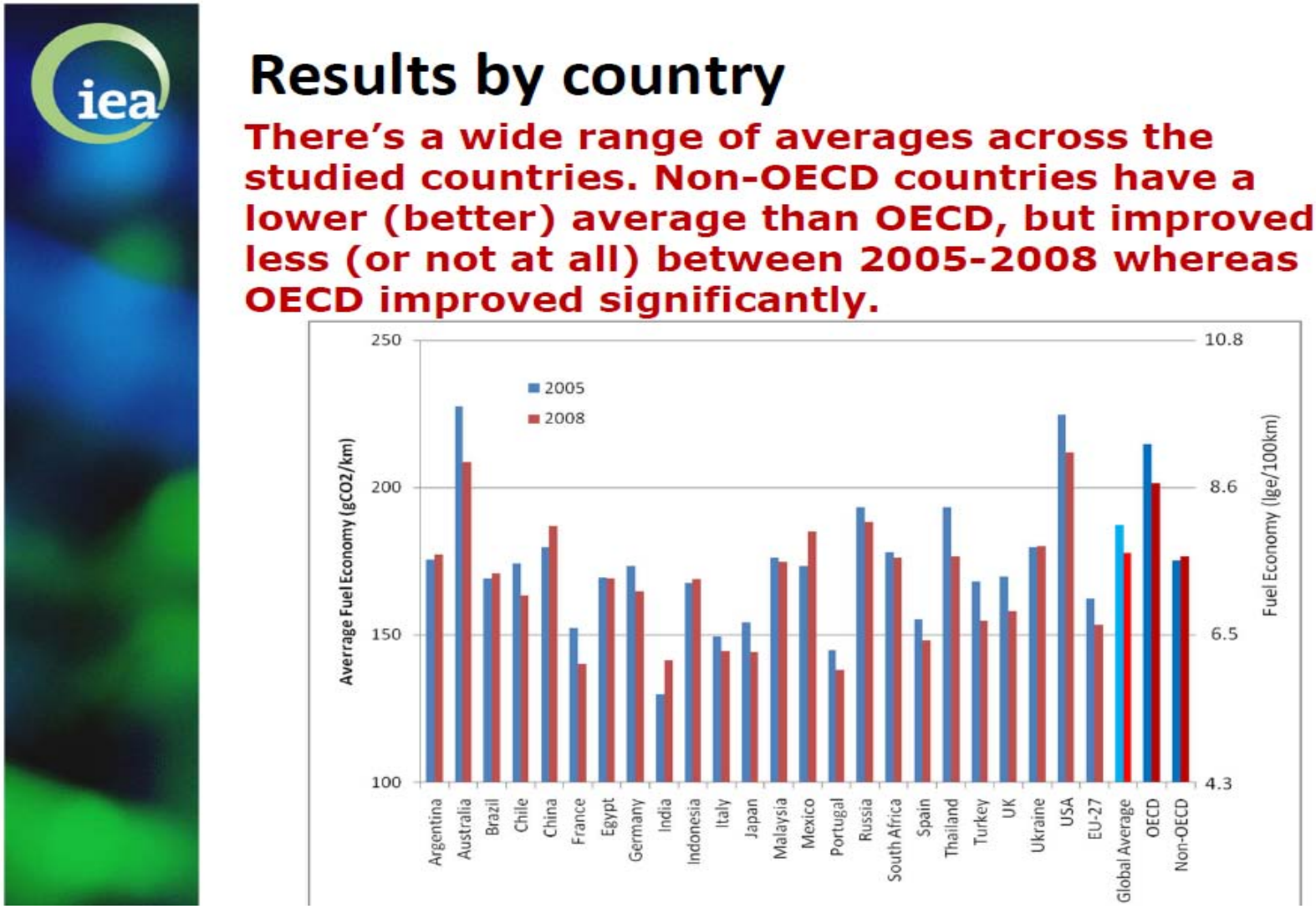
Light Duty Vehicles (LDVs) were defined as the group of vehicles with a gross weight of less than 3500 kg.

[4]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].

APPENDIX 8.5: IEA study on OECD and Non-OECD countries, fuel consumption and CO_2 emission Standards



APPENDIX 8.6: 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	

APPENDIX 8.7: 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**

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

APPENDIX 8.8: 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 - 2014*

APPENDIX 8.9: 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 FACTYPE	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. ……
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

APPENDIX 8.10: Petrol Powered Motor Vehicle Emission Standards

Vehicle Class and Model Year	*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:		
Gross vehicle weight of 6001 pounds to 10,000 Pounds		
1975-1977	750	6.5
1978-1979	600	5.5
1980	400	4.5
1981-1984	300	3.0
1985 +	200	1.2

APPENDIX 8.11: 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 a drive wheel speed of 50 mph (±2mph).
   b. A diesel-powered vehicle with a net weight of 6000 pounds or less shall be 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 5 consecutive seconds or more when under the applicable loading.

   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.