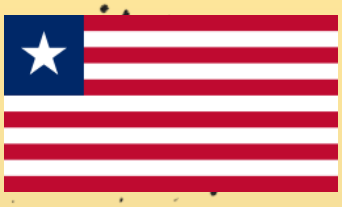

Report on Liberia's Fuel Economy and Vehicle CO2 Emission

EPA-Liberia

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LIST OF ABBREVIATIONS

GFEI	Global Fuel Economy Initiative
UNEP	United Nations Environmental Program
IEA	International Energy Agency
FIA	Internationale de L' Automobile
ITF	International Transport Forum
LRA	Liberia Revenue Agency
MOT	Ministry of Transport
LDV	Light Duty Vehicle
NEDC	New European Driving Cycle
CAFÉ	Corporate Average Fuel Economy
JCO8	Vehicle Fuel Consumption measurement based on approval in Japan

Executive Summary

The Global Fuel Economy Initiative (GFEI) is a project aimed at reducing localized air pollution, greenhouse gas emission and global national fuel bills through the promotion of cleaner fuel efficient vehicles. The GFEI is a joint initiative of the United Nations Environmental Program (UNEP), the International Energy agency (IEA), the Internationale de l'Autobile (FIA), and the International Transport Forum (ITF) calling for the adoption of a global fuel economy roadmap, which should be embarked upon urgently and integrated into financial support of the global car industry.

In February 2017, the Environment Protection Agency of Liberia signed an agreement for the analysis and interpretation of baseline data gathered on vehicle fleet in Liberia under the GFEI project. As part of the analysis and interpretation the following areas were studied:

(I) Vehicle Statistics

- Study was conducted on the registry of vehicles for the years 2005, 2008, 2011, 2013 and 2015. These vehicle registration record were obtained from the Ministry of Transport and the Liberia Revenue Authority (LRA), the two main custodians of data related to vehicle importation and registration.
- The average fuel economy for Liberia was established to be 7.8L/Km with a corresponding average CO2 emission of 152.2g/Km. Comparing this with the global average of 7.2L/100Km it is shown that Liberia's average fuel economy is higher and is not improving.

- The significant increase in the number of used vehicle with no record of hybrid vehicle imported in country is an issue of concern. This is unusual. However, it could be attributed to lack of adequate public awareness as is the case with Kenya.

- The record of vehicles registered since 2005 and observations made are as follows:
  1. During the period under study, 90% of the vehicles were manufactured in Japan and Germany and 10% in the United States of America.
  2. The number of used vehicles in the fleet continues to increase. The study established that 89.7% of Vehicles were used and 11.3% were new. The average age of vehicles imported into the country is 10 years old.

3. On the basis of this trend, and based on extrapolation of best line of fit, the total number of Light Duty Vehicles could reach 913,853 by 2050. This also conforms to R. Gakenheimer 1997 study that "in much of the developing world, the number of motor vehicle is increasing at more than 10% per year."

(II) Recommendation

The study has developed sets of recommendations to enhance data management including acquisition, processing, interpretation and storage. The Ministry of Transport and the Liberia Revenue Authority should establish a framework to:

- Compute a complete registry of motorcycles in the country
- Implement existing policies.
- Update all databases on vehicle registry into a digitized form.
- Capture vehicle model, engine size, fuel economy, body type, engine type etc. This can be achieved by establishing a separate data entry office in addition to that which is already existing to make it possible for less assumptions to be made in the future.
- Create an electronic registration systems or digitized the registry to make retrieval of vehicle data relatively faster and more efficient.

1.0 Introduction

1.1 Background

The Global Fuel Economy Initiative (GFEI) has determined that improving fuel-efficiency of road vehicles is one of the most cost effective and feasible measure for stabilizing carbon dioxide (CO_2) emission from road transport. It further estimate that global vehicle fleet is expected to reach around 3 billion vehicles in 2050 with most of the vehicle growth taking place in developing countries. 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).

Additionally, the National Geography Magazine (2007), mentioned among other things that "carbon dioxide (CO_2) comes from thermal power plants that generate electricity, transport vehicles fueled by petrol (gasoline) and diesel and industrial combustion processes." In order to reduce (CO_2) emission impacts on human health, environment and climate focus has been placed on reduction of Greenhouse Gas emission.

Liberia relies on fuel importation, and given this increase in the global fleet to which the country is a part, there will be an increased pressure on the country's national budget. Thus, improving fuel efficiency will contribute to lowering dependency on expensive imports and reduce high fuel expenditures and subsidies. (GFEI Study on Kenya, 2015).

As part of expanding its program, GFEI, in 2016, included Liberia as one of its pilot countries to assess fuel economy and CO2 emissions from LDVs as a means of understanding the impacts from the sector, which could trigger evidence-based policy decision. After participation into its high-level networking event, the Environmental Protection Agency of Liberia (EPAL) was approved for a Small Scale Funding Agreement (SSFA) to estimate fuel economy and CO2 emissions from LDVs. This report contains results from one of the expected outputs of the project.

1.2 Objectives of the study

The objective of the study was to conduct in-country-study which identifies barriers, gaps and needs for the development of average fuel efficiency and carbon dioxide level for Liberia.

1.3 Scope of work

The scope of the study is to analyze and interpret baseline vehicle inventory data to establish the average fuel economy in Liberia. In line with the Globe Fuel economy Initiatives (GFEI) methodological guide, the following data were analyzed:

a.) Number of vehicles imported in 2005, 2008, 2011, 2013, and 2015 (both old and new vehicles)
b.) Vehicle composition (passenger cars, trucks, buses, and motorcycles);
c.) Vehicle age distribution of existing vehicles
d.) Vehicle model and inbuilt technology available
And
e.) Fuel efficiency of vehicle stock at respective times of registration (both used and new vehicles) in 2005, 2008, 2011, 2013, and 2015.

The benefits to the country is to reduce fuel bill, reduce air pollution (as fuel efficiency also emit less pollution) and also climate benefits due to reduce CO2 emission.

2.0 Vehicle Statistical Analysis and Interpretation

As a basis for conducting the study, the data availed was collected from the Ministry of Transport (MOT) and the Liberia Revenue Authority (LRA). These data consisted of a total of 109,770 (one hundred nine thousand seven hundred seventy) LDVs, compiled in approximately 110,000 rows of MS Excel datasheets. It is significant to note that the LRA, an operational arm of the Ministry of Finance and Development Planning (MFDP), only became functional in 2009/10. It has a repository of vehicle data that covers 2011-2015. The MOT data was more detailed as it covers the entire period of the study 2005, 2008, 2011, 2013, and 2015. The procedure used as guidance by the consultant was based on the Methodological Guide to Developing Vehicle Fuel Economy Databases prepared for the Transport Unit of the Division of Technology, Industry and Economics of the United Nations Environmental Program (UNEP) by Climate XL Africa.

About 11.3% of LDVs were new and 89.7% were used.

2.2 Size of Data

This study analyzed inventory of all LDVs registered in 2005, 2008, 2011, 2013, and 2015. The data availed was scanty; a large portion only included vehicle composition (trucks, taxis, and commercial). Some portion of the data have variables model of LDV in a variable represented by the following descriptions:

1. Vehicle Category

2. Type (Used/new)

3. Identification number

4. Model

5. Year of Production

6. Fuel type

7. Engine type

8. Engine size

9. Body type

10. Carbon dioxide emission

11. Fuel economy

12. Vehicle use

2.3 Data Processing

The data was cleaned to remove typographical errors and separating new and used vehicles to make it conform as much as possible to GFEI database guidelines. Because of the nature of the data, projections were made in cases where variables were missing.

In some cases, the data had missing fields i.e. where model was missing, vehicle make was included. There were cases where the registry had vehicle composition only; i.e. commercial, buses, trucks and taxis. This was rectified before performing search for their fuel economy and CO_2 emissions. The vehicle model is key to this exercise because on the major websites classification of fuel emission and CO_2 emission is based on model names. In the case where the model year of manufacturer of LDV was absent, the nearest year was used to populate the database. All other missing items from the data fields were populated. Resolving the issue of used and new vehicles was key to avoid vehicles registered each year from repeating in the data. The case of Kenya (8 years) was adopted in this study.

Moreover, all vehicle fuel economy data were converted to L/100Km and CO_2 emission in g/Km. The average vehicle fuel consumption levels were obtained from manufacturers' websites while NEDC, CAFÉ, and JC08 were used for the study. The preference for the NEDC was based on the successful used of this test cycles by Kenya.

2.4 Study Assumptions

The following assumptions were developed in the study:

1. Extrapolation was considered by the consultant to develop trends of fuel economy and CO_2 for three wheelers, passenger cars, trucks, buses and min-buses, vans, pickups.
2. Where data on vehicle make and models were not available, especially in the case of old vehicles, data on the closest model was used on the assumption that there would be marginal variance between one generation model and subsequent one.
3. Vehicles of over eight (8) years that appeared in the data were considered to be registered after use by other groups which may include Non-Governmental Organizations, (NGO), United Nations (UN) and other governmental agencies.
4. Even though the fuel economy and CO_2 of motor cycles are of different magnitude, they were included in the data as LDVs.

2.5 Populations Trends of Vehicles.

Results of the study and trends derived from the vehicle population, fuel emissions and CO_2 emissions are presented in this section as figures and tables.

The trend of used and new LDVs registered for the period 2005, 2008, 2011, 2013, and 2015 can be seen in table 2-1. From this table, a linear graph and bar graph was derived to further establish a trend as can be seen in figure 2-1 and figure 2-2.

	2005	**2008**	**2011**	**2013**	**2015**
New	2380	4321	1731	2467	3577
Used	5092	17287	15630	28365	28945
Total	7440	17365	21609	30832	32522

Table 2-1: Number of new and used LDV population

	2005	2008	2011	2013	2015
New	32%	20%	10%	8%	11%
Used	68%	80%	90%	92%	89%

Table 2-2: percentage of new and used LDVs

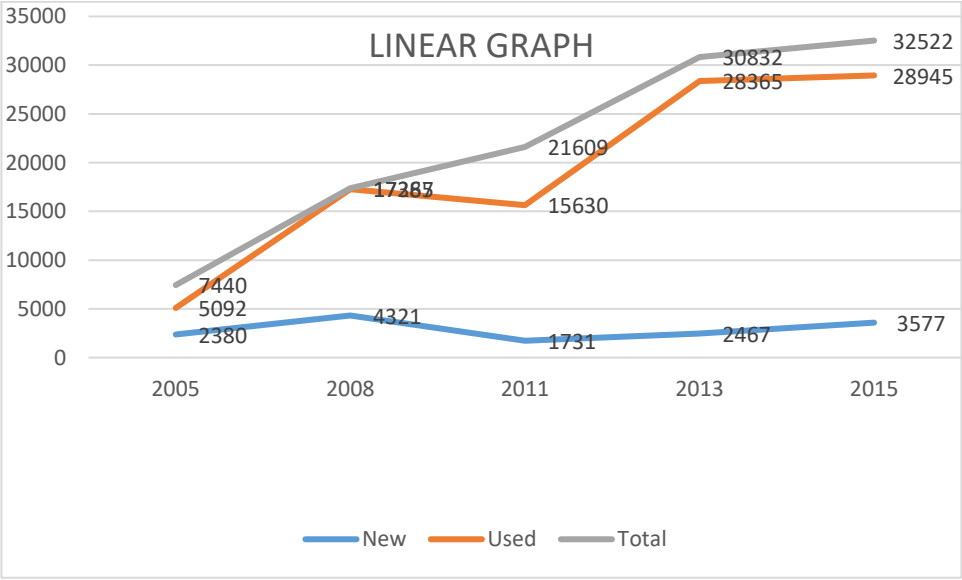


Figure 2-1: Linear chart representing number of LDV population

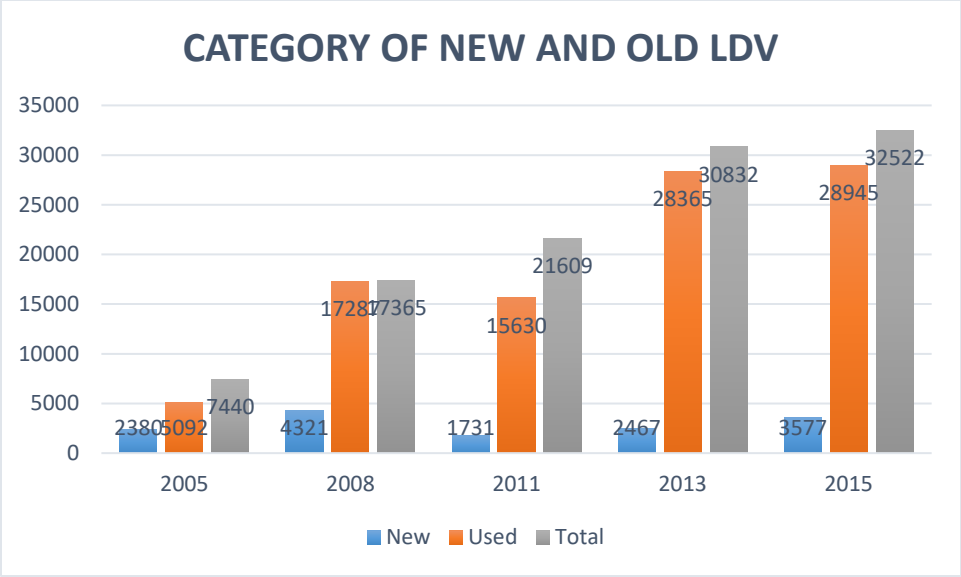
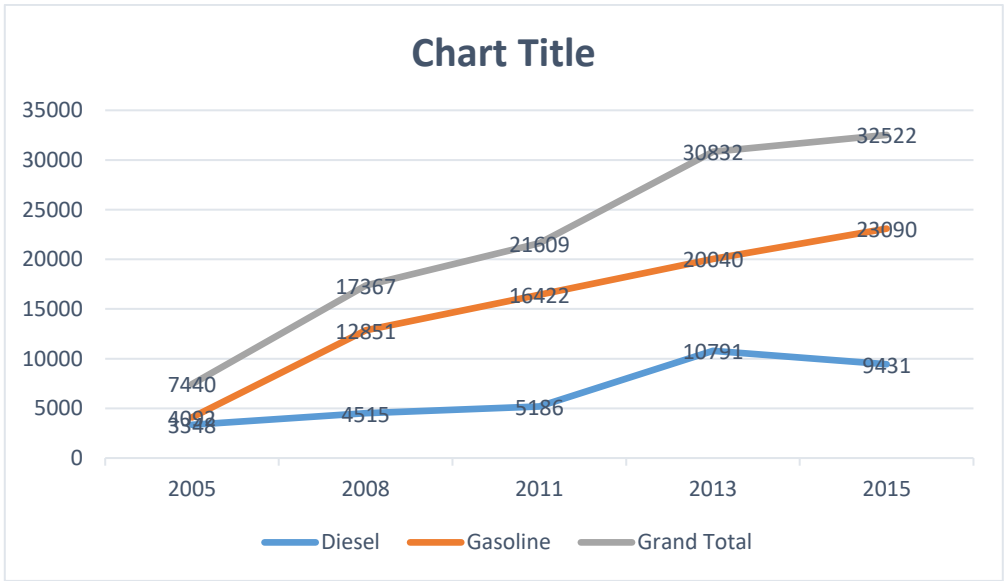


Figure2-2: Number of New and use LDVs population



Extrapolation based on the data shows that there is a continuous increase in the importation of used vehicles over new ones. Taking into consideration the total number of fleet of all types of vehicles registered as presented by the data, the increase in the importation of used vehicles is expected to continue at a rate of about 10% given the best line of fit and continuation of the trend. Based on the trend, the total number of LDVs by 2050 is estimated to be 913,853. However, it is recognized by the study that "in much of the developing countries, the number of motor vehicle is increasing at more than 10% per year. The significance of such a rate of motorization is that related systems such as infrastructural development like road network cannot keep pace with it". (Gakenheimer R. 1997).

	2005	2008	2011	2013	2015
Diesel	3348	4515	5186	10791	9431
Gasoline	4092	12851	16422	20040	23090
Grand Total	7440	17367	21609	30832	32522

Table 2-3: Number of LDV by fuel type

Figure 2-3: Trend representing number of new and used LDV:

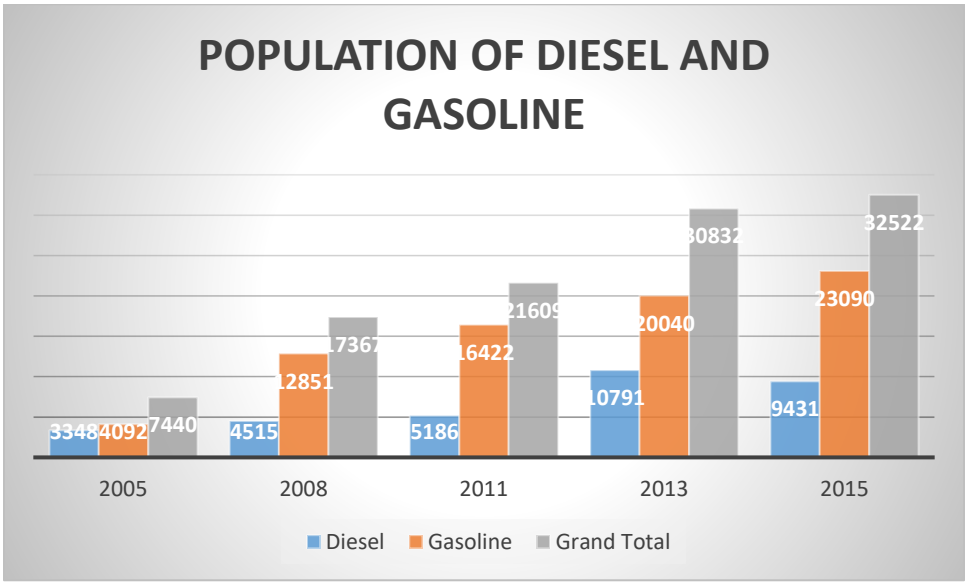


Figure 2-4: Number of LDV powered by diesel and gasoline

As indicated in table 2-2 and figure 2-3 the study has established that there is a less infinity for LDVs powered by diesel. Study conducted by the European Commission in 2013 shows that there is a reduced energy consumption and CO_2 emission in the transport sector through dieselization which resulted in increased ratio of diesel to gasoline. Dieselization is a term used to represent the percentage of diesel cars in a total car fleet.

Percentage of LDVs Powered by Gasoline and diesel

	2005	**2008**	**2011**	**2013**	**2015**
Diesel	45%	26%	24%	35%	29%
Gasoline	55%	74%	76%	65%	71%

Table 2-4: Percentage of LDVs powered by Gasoline and Diesel

The cause for LDVs powered by gasoline was not established by this study. A closer look at the current policy on vehicle importation and taxes could establish some lead with this premise.

Car Make	**2005**	**2008**	**2011**	**2013**	**2015**
Mitsubishi	1190	463	1369	411	1518
Chevrolet	74	116	72	308	1409
Toyota	3869	3821	5546	13360	15600
Nissan	893	6098	10805	12333	10841
Isuzu	223	463	144	103	108
Dodge	49	0	360	308	108
Ford	223	232	792	617	867
Land Rover	25	58	0	0	108
Hyunda	298	116	576	822	542
Daewood	25	58	0	0	0
Mercedes benz	223	116	360	308	108
Kia	99	116	144	103	434
BMW	0	174	0	0	0
Cherokee	0	232	0	103	0
Diahatsu	25	58	72	0	0
Peugeot	0	174	0	514	108

Sabaru	25	374	0	0	0
Fait	0	58	72	0	0
Range Rover	0	58	0	0	0
Volkswagon	0	58	216	103	217
Suzuku	25	58		0	0
Honda	25	57	144	308	542
Renault	25	868	216	308	217
Madza	23	374	216	0	108

Table 2-5: Number of LDVs by car make

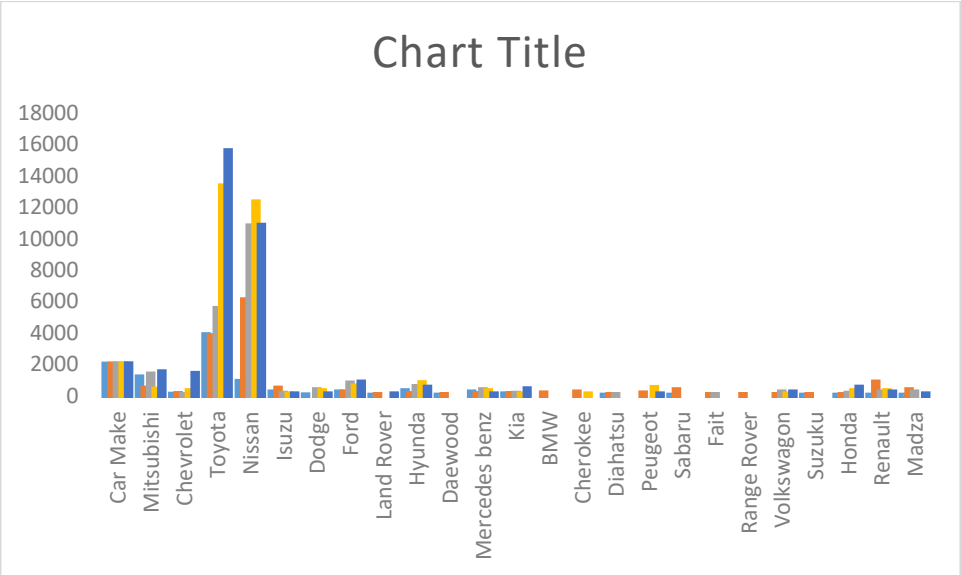


Figure 2-5: Trends of registered car make population per year

Table 2-4, figure 2-4 and 2-5 show data on the different make of vehicle registered during the study period. The data shows that Toyota, and Nissan has the highest number of vehicle in the fleet. Others as shown in the data represent the number of motorcycles.

Figure 2-6 and Table 2-5 show the average age of LDVs registered over the period study. This demonstrate the average age of vehicles registered on the road. As indicated, the average age of LDVs registered in Liberia is 10 years.

Year OF PRODUTION	Number of vehicles registered
1986-1990	14123
1991-1995	9367
1996-2000	32491
2001-2005	21588
2006-2010	33955
2011-2015	6220

Table 2-6: Number of vehicles registered by year of production

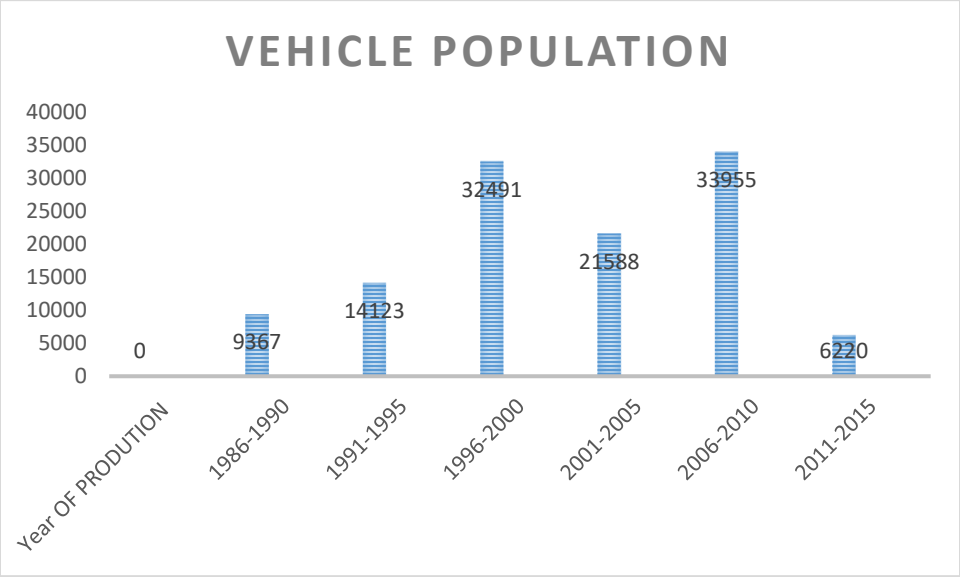


Figure2-6: Number of vehicles registered and year of production

2.6 Fuel Economy and CO2 emission

There are test procedure to determine fuel economy and GHG emission from new passenger vehicles. This is based on published manufacturer's data when computing vehicle stock fuel economy. The main fields for data for development of vehicle fuel economy databases of the fuel consumption in L/100km and CO2 emission in g/km were sourced primarily from US, European and Japanese government websites. The fuel consumption values are based on the New European Drive Cycle (NEDC) and where other test cycles were used the global standards review conversion factor was used to obtain an NEDC equivalent. Each year of the study period, 2005, 2008, 2011, 2013, and

2015 the total number of LDVs per year was 7440, 17364, 21609, 30,832, and 32,522 respectively

The indications from Table 2-6 and figure 2.7 show that the average fuel consumption for vehicles in Liberia is 7.93L/100km with a corresponding CO_2 of 179.08 g/Km. This shows trends in fuel consumption for the period of the study. It indicates a slight improvement in fuel consumption for Liberia. This can be attributed to marginal increase in the importation of new vehicles with improved technology and better mechanical condition of vehicles.. The total number of registered LDVs that were considered used constitute 89.7% and 11.3% were considered new. Gasoline engines were established to be most prevalent constituting 67.9% and 32.1% were powered by diesel. Emerging trend was developed in terms of projection for the total number of LDVs that would be registered by 2050.

Year	Average fuel consumption(L/100Km)	Average CO2 emission (g/Km)
2005	7.89	181.43
2008	8.12	182.99
2011	7.96	179.08
2013	7.93	178.29
2015	7.79	177.76
Total average	7.93	179.08

Table 2-7: Average of fuel consumption and CO2 emission per year

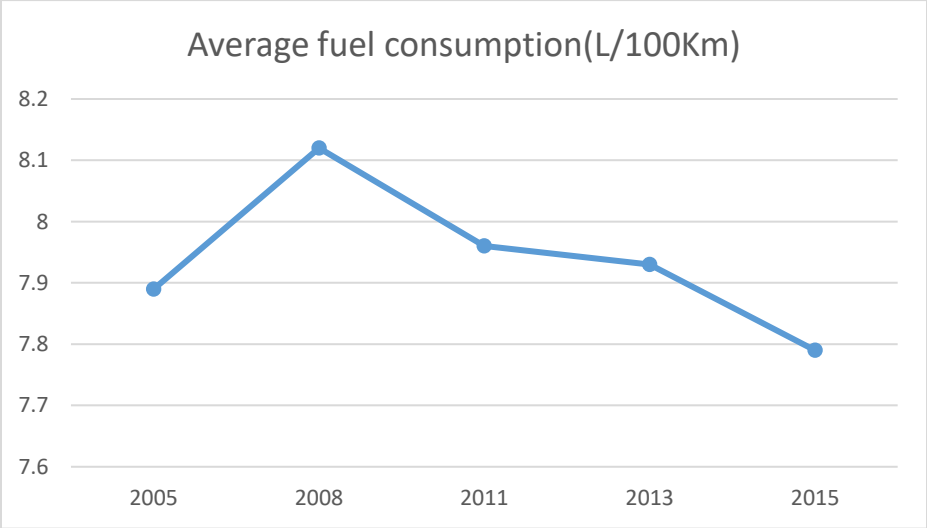


Figure2-7: Trends of Average fuel consumption per year

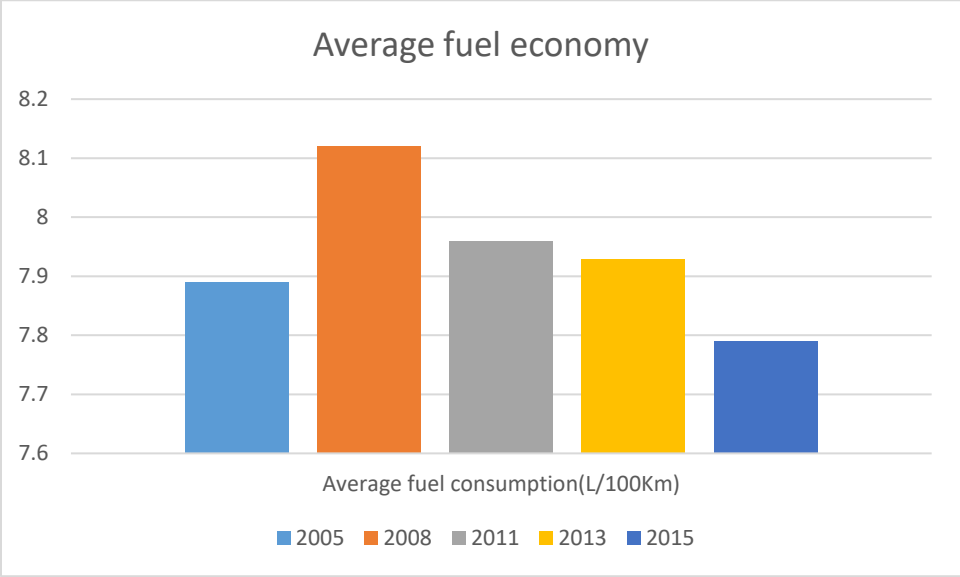


Figure 2-8: Trends of CO_2 emissions per year

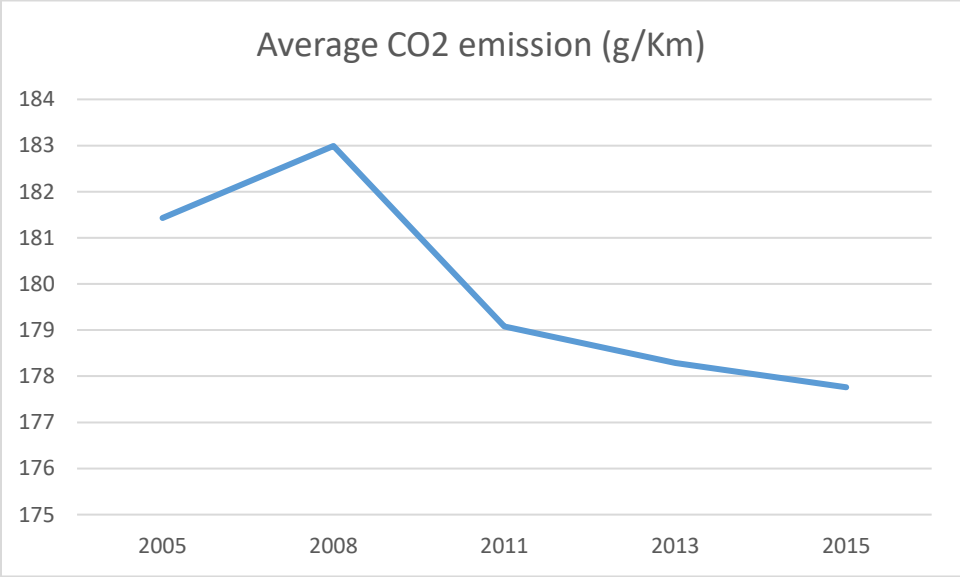


Figure 2-9: CO_2 emission by year

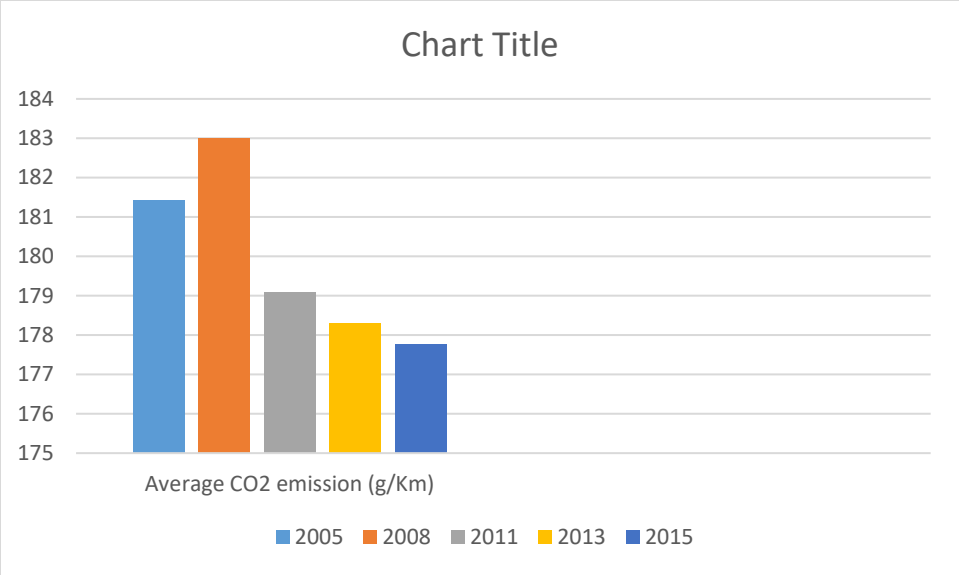


Figure 2-10: Average CO_2 emission.

2.7 Vehicle In-Built Technology

Table --- shows engine size (displacement) of vehicles

Year of Production	2005	2008	2011	2013	2015
1100ccc-1500ccc	1,215	2,141	4,393	3,288	1,951
1600cc-2000ccc	3,150	9,030	11,020	17,574	117453
2100cc--2500ccc	546	1,620	3,097	7,399	5,637
2600cc-3000cc	2,009	1,274	1,368	1,438	2,059
3100cc-3500cc	24	753	432	924	2,059
3600cc-4000cc	49	174	285	0	108
4100cc-5000cc	446	463	576	205	0
<50000cc	0	116	432	0	0
125cc	0	1,737	2,160	0	3,252

Table 2-8: Engine size (displacement) of registered LDVs

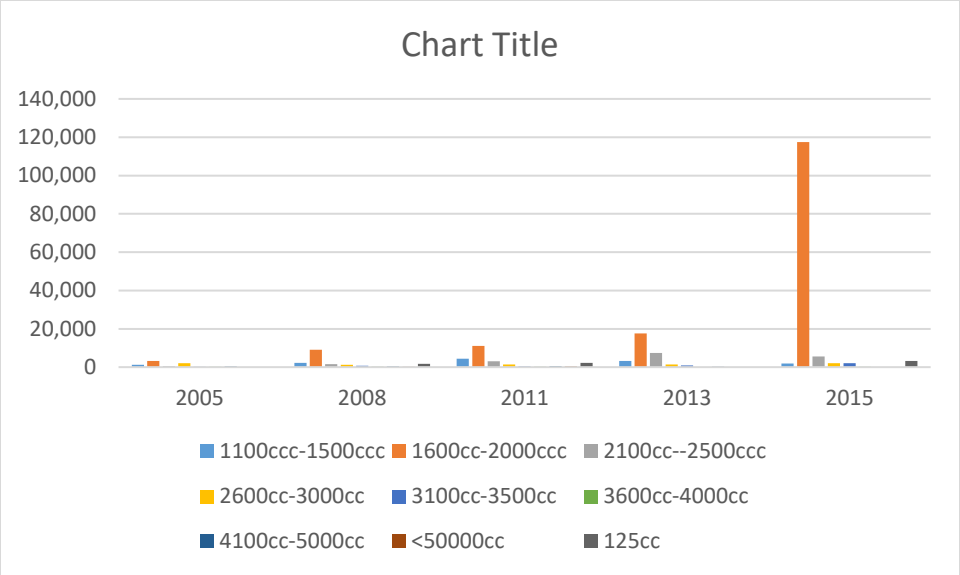


Figure 2-11: Population of engine size (displacement)

3.0 Conclusions on Vehicle Inventory

A critical analysis of the research data was done and practical recommendations offered that will serve as an instrument that can be used in future studies of vehicle fuel economy in Liberia whilst serving as a tool for informed decision making to enhance policy development and implementation. During my analysis, Gasoline engines were established to be the most prevalent LDVs with a preferred engine size range of 1600cc to 2000cc; No hybrid vehicle was registered in the database. This is considered to be unusual; Motorcycle became prominent from 2008 to 2015. The sudden introduction and increase in population is due to its convenience. The challenge was to use the database to establish a projection base on best line of fit. However, comparing the trends in vehicle registration with other developing countries it was projected to increase at 10% given study conclusions. (Gakenheimer R. 1997), and that the total number of LDVs will increase to 913,853 by 2050. Therefore, actors such as donor governments, Non-governmental organizations and Government of Liberia must work together to improve fuel economy in a sustainable manner. External actors can play a more effective role by providing knowledge and experience of the issues of fuel emission and techniques to curtail CO2 emission through vehicle fuel emission.

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