

General Knowledge of Liquefied Petroleum Gas (LPG) Powered Vehicle Users in Ghana: A Case Study of Tema Community 1

Abstract

Globally, there is an increasing number of vehicles being manufactured to run on LPG. Its tendency to decrease exhaust emissions and thus increase profit for commercial vehicles has endeared it to many commercial drivers. The commonest means of transportation in the Tema metropolis, Ghana, is by commercial taxis. It is estimated that about 1 200 taxis are actively running on LPG in the metropolis. Currently, most of the taxis originally designed to run on gasoline have converted to run on LPG without any approved regulations. Unfortunately, the conversion is often carried out by unqualified mechanics which the aftermath may pose safety concerns to users. The vehicle regulatory (Driver Vehicle and Licensing Authority) have expressed its concern over their inability to exercise regulatory authority over converted LPG operated vehicles as well as lack of gadgets to check the safety of the vehicles especially for leakages. This research therefore assessed the knowledge of LPG powered vehicle users in the Tema Community 1 metropolis. Questionnaires were distributed amongst 100 LPG powered vehicle users to sample their views on LPG safety knowledge in their vehicles. It has been proven that 81% of LPG vehicles in the metropolis were converted from an originally run gasoline fuel. Also, the only means for leakage detection employed by most LPG vehicle drivers is by the use of smell which is unreliable. The users show poor to modest safety knowledge on LPG usage. It is recommended that LPG powered vehicles should be converted by certified engineers, inspected regular and LPG safety devices installed in such vehicles for safety purposes.

1.1 Introduction

The running cost of Liquefied Petroleum Gas (LPG)-driven vehicles is lower than petrol-driven and diesel-driven vehicles in many territories mainly due to lower fuel tax rate on LPG (Liu *et al.*, 1997). In spite of its relatively higher combustibility and dangers associated with leakages, autogas or LPG is widely used as green fuel. In particular, it reduces carbon dioxide emissions by around 35% compared to petrol. One litre of petrol produces 2.3 kg of carbon dioxide when burnt, whereas the equivalent amount of autogas produces 1.5 kg of carbon dioxide when burnt (Tyler, 2010). Globally there is an increasing number of vehicles being manufactured to run on LPG. Studies show that as at 2010, there were about 12.7 million natural gas vehicles worldwide (Anon, 2010). Aside the risk of explosion, exposure to LPG can cause dizziness or cardio-respiratory arrest in humans (Anon, 2010).

The commonest means of transportation in the Tema metropolis is by commercial buses and taxis but the taxis are the main cars being used

within the city of Tema. It is estimated that about 1 200 taxis are actively running on LPG in the metropolis. This constitutes about 75% of the estimated 1 600 taxis actively running in the Tema metropolis (Tettehfiio *et al.*, 2014). Most of these taxis were originally designed to run on gasoline. Unfortunately, their conversion to run on LPG are not regulated. There are no standard ways of detecting leakages after the alterations in most of these vehicles posing a high safety risk to both the occupants of the vehicle and possible passers-by (Anon, 2014; Tettehfiio *et al.*, 2014). This safety risk includes fatal fire explosions, dizziness and cardio-respiratory arrests. The importance of technical knowledge of LPG powered vehicle users cannot be overlooked as it will enable Driver and Vehicle Licensing Authority (DVLA) and other regulatory bodies to exercise regulatory authority over LPG operated vehicles. In this regard, the DVLA can enact laws to govern the conversion and usage process within the study area.

1.2 Location and Accessibility

Tema is a city located 25 kilometres east of the capital city; Accra, in the region of Greater Accra, and is the capital of the Tema Metropolitan District. The population of the metropolitan area is projected at 402 000 with an annual growth rate of 2.6%. The Greenwich Meridian passes directly through the city. The latitude of Tema is 5.666667, and the longitude is 0.000000. Tema has an elevation

1.3 Transportation and Road Networks

The total length of roads within the Metropolitan area is 1 237 km (including Kpone-Katamanso which has been carved out since 2012), made up of 38 km asphaltic concrete, 301 km surface dressed and 898 km gravel and earth roads. The main mode of transporting goods and services in the Metropolis is by road (Ababio *et al.*, 2014). Due to the location of the harbour, a lot of shipping companies operate in the Metropolis that facilitate the export and imports of goods from other countries.

There are private and commercial transport systems operating in the Metropolis, including, a web of taxi services which are available 24-hours. Heavy-duty trucks and Lorries come from all over the country carting goods to and from the harbour and the industries in Tema. Basically, there are four types of commercial transport systems in the Metropolis; these are bus, commercial vehicles, shared and hired taxi services. All transport activities both within and intercity, originates and terminates at the various vehicle terminals and station at Community 1 which is also known as the Central Business District (CBD) of the city (Anon, 2010a).

2.1 Liquefied Petroleum Gas

Liquefied Petroleum Gas (LPG) describes flammable hydrocarbon gases including propane, butane and mixtures of these gases. LPG, is liquefied gas through pressurisation and comes from natural gas processing and oil refining. It is a fossil fuel that does not occur in isolation. LPG is found naturally in combination with other hydrocarbons, typically crude oil and natural gas. The typical

of 19 meters height (62 feet). It is locally nicknamed the "Harbour Town" because of its status as Ghana's largest seaport. The Metropolis covers an area of about 87.8 km² with Tema as its capital. The metropolis lies in the coastal savannah zone. The Ashaiman municipal is an inlock enclave of the Tema metropolis.

LPG gases- propane and butane are regarded as Natural Gas Liquids (NGLs). However, not all NGLs are LPG. LPG is otherwise known as autogas which is a product of petroleum refining primarily. Propane is the most common type of fuel for internal combustion engines after petrol and diesel.

LPG is an eco-friendly fossil fuel choice as it is a low carbon (lower CO₂ emissions than other fossil energy sources), low sulphur fuel, versatile, and transportable. Using LPG requires very little infrastructure, which makes it an excellent choice for developing countries, as well as developed countries (Liu *et al.*, 1997).

LPG has numerous uses. Its uses are seen around the home, in vehicles and for businesses. Heating, cooking and hot water are the most common domestic uses. It is also employed as a propellant, refrigerant, vehicle fuel and petrochemical feedstock. Crop and produce drying, heating greenhouses, hot water for dairies, irrigation pumps and heating animal enclosures are just some of the agricultural applications for LPG. Transport is also a big user of LPG (Autogas), either as propane or propane mixed with butane, to power various vehicle types. LPG is increasingly being used as an aerosol propellant and a refrigerant replacing chlorofluorocarbons in an effort to reduce damage to the ozone layer (Tyler, 2010)

2.2 The Ghana LPG Promotion Programme

The LPG Promotion Programme was introduced in 1990 as government's intervention to reduce the overdependence on traditional wood fuels for cooking and other household applications. To this effect, the promotion was characterised by certain features put in place to ensure delivery of its

intended goal. The promotion chalked some successes and also faced some downsides (Ahiataku-Togobo, 2002). Tema Oil Refinery (TOR) and other bulk distributing companies are responsible for LPG supply in the country. LPG is sourced from TOR during refinery of petroleum products and through imports. Currently, Ghana's domestic consumption of LPG is over 100 000 tonnes per annum, which is about sixteen times higher than the quantities consumed before the LPG Promotional Programme was launched. Annual consumption of LPG reached a peak of 251 800 tonnes by 2013.

2.3 Advantages and Disadvantages of Using LPG in Vehicles

LPG has its advantages and disadvantages when compared to other fossil fuels like petrol and diesel. There are many advantages which can be associated with LPG. These include; Autogas cars emits 20% less carbon dioxide than their petrol counterparts. This helps in reducing the chances for global warming.

- i. Autogas cars emit very less quantity of Nitric Oxide. The sound pollution is minimised with Auto gas powered cars as they produce less sound compared to a diesel engine.
- ii. There is no risk of water or ground contamination in case of a fuel spill. As the Auto gas will evaporate very quickly leaving nothing behind.
- iii. As the LPG fuel is found naturally as a by-product of gas extraction, their production does not result in any environmental imbalance.
- iv. Auto gas cars are found to emit only 120 times lesser fine particles compared to diesel fuel.
- v. Auto gas contains only very less amount of sulphur. The most practical solution to avoid harmful emissions from a car is to convert it into an Auto gas powered one.

The disadvantages that LPG usage in vehicles pose are minimal as compared to its advantages. It has been generally agreed that the major disadvantage of LPG is the limited availability in different countries. When it comes to using LPG in vehicles, it is known to shorten the life of an engine (Anon, 2012). This is due to the fact that LPG lacks

combustive properties with lead and lead substitutes. LPG has a high expansion factor and due to this, partial filling of the tank is recommended usually to about 80% of the total tank capacity (Arcoumanis, 2000). LPG is dangerous when allowed to accumulate in small spaces and enclosures as well as poorly ventilated garages. Also sufficient amount of gas can cause asphyxiation due to quick displacement of oxygen (Liu *et al.*, 1997). The LPG tank usually fitted at the boot of a car takes a considerable amount of space. Since LPG is highly inflammable, it often times damages valves of the vehicles. Finally, it is reported that the initial cost of conversion for switching to LPG fuel is very high for domestic vehicles (Anon, 2013a).

2.4 Conversion of LPG Powered Vehicles in Ghana

Conversion of petrol fuelled vehicles to LPG in Ghana is often carried out by mechanics who are not professionally trained (Anon, 2013b). Although this practice is on the increase with a lot of vehicle owners opting for this; commercial car (taxi) owners' making a huge profit after converting petrol car to use LPG as fuel, they are facing the challenge regarding safety issues associated with the practice. In addition, the efficiency of the converted fuel supply system of the LPG is also questionable. This is because, most of the LPG mechanics do not have the standard diagnostic tools and conversion kits needed for the efficient conversion hence could easily lead to system failure; affecting the performance of the vehicle (Tettehfiio *et al.*, 2014). According to an interview with a workshop supervisor at Don Bosco Training Institute, a private institution for training automobile engineers, installation of LPG in a vehicle normally takes only one day. This is because their garage is well equipped with the standard conversion kits which enable installations to be easier and efficient at the institution. Furthermore, they have diagnostic kits which are used to check the electronic and electrical system of the vehicle before installation commences. Unfortunately, most vehicles owners are not aware of it and those who are aware hardly patronise the place due to financial challenges.

2.5 Safety Measures in Handling Automotive LPG

To enhance safety in using LPG, regulations or codes of practice are introduced to regulate the safe handling of LPG, the use of LPG vehicles, the design and construction of LPG fuel tanks. The regulations impose restrictions on LPG refuelling stations, impose requirements for regular inspection of LPG vehicles as well as proper training of personnel handling LPG.

2.5.1 Fuel System

The main purpose of the regulations governing the fuel system of LPG vehicles is to prevent leakage, minimise the possibility of accidents and reduce damage in case of accidents. The regulations mainly require the conversions to be done by authorised persons. Regular inspections including a check of LPG leakage along the fuel system are to be done by approved technicians. Materials and thickness of fuel tanks are to follow specifications and various parts of the fuel tanks are to include devices such as liquid level indicator, overfilling prevention device, safety relief valve and emergency shut-off valve.

2.5.2 Refuelling Stations

Refuelling stations have to be designed to meet safety codes. This is because a large amount of gas is stored at refuelling stations. Prior inspection of the site and regular inspection by safety officers to ascertain the integrity of the station is highly recommended (Liu *et al.*, 1997). They should also ensure that the vessels into which they are discharging fuel are safe to use.

2.5.3 Training of Personnel and Competence Requirements

Proper training of personnel handling LPG is important in ensuring safety in using the fuel. Most territories require the operating staff of refuelling stations as well as repair and maintenance staff to be trained and registered by recognised bodies. Personnel working with LPG must know where system components are located and be aware that some parts contain liquid LPG whereas some other parts contain

vapourised LPG. In either case, the LPG will be at elevated pressure (Anon, 2013c). Removal of component parts like the gas motor and cylinder for servicing should be only done by trained personnel. A comprehensive set of rules concerning the safe handling of LPG must be developed. Strict compliance to these rules ensures safety in using LPG.

3.1 Data Collection

For this research work, questionnaires and structured interviews were used. As a precaution for detailed and unbiased responses, both closed and open ended questions formed part of the questionnaires. A research team was formed to collect the data. Prior to the set days for data collection, permission was sorted from the various taxi station heads. They then informed the drivers of the visit. This made it easier to obtain the information.

3.2 Data Type

Several methods were used to collect information from respondents. No single source of data has a complete advantage over the others and also the various sources of data collection are highly complementary (Yin, 2003). The combination of different methodologies to examine the same phenomenon is known as triangulation. Through triangulation, a researcher can improve the accuracy of results by collecting data through different methods or even collecting different kinds of data on the subject matter of the research (Ghauri and Gronhaug, 2003). Both primary and secondary data were employed in this study. Primary data was obtained from the LPG powered vehicle users whereas secondary data was obtained from existing work published on this study, media reports and Ghana National Fire Service documents.

3.3 Data Analysis

Data was edited and coded for entry into a computer using Statistical Package for Social Scientists (SPSS) version 2.0. Editing involved the inspection and correction of questionnaires. Both qualitative and quantitative analysis was employed in this

study. The data was categorised and tabulated to address the purpose of the study.

4.1 Results

Information gathered included perspectives of the various LPG powered vehicle users with reference to choice of LPG as a fuel, place of manufacture of cylinder, period of usage, types of pipes, expiry date of pipes and cylinders, pressure rating, capacity of cylinders, safety knowledge, leakage detection *etc.* The responses from the users are presented thereafter.

4.2 LPG Powered Vehicle Types

The vehicle types that were assessed for the purpose of the research work are presented in Fig 4.1. The CBD of Tema community 1 is the hub of many businesses in the metropolis, as a result actively running LPG powered commercial saloon cars are predominant, followed closely by private saloon cars. Commercial trucks lag behind partly because majority of the commercial trucks run on diesel fuel. 75 respondents out of the total of 100 LPG powered vehicle users interviewed corresponding to 75% of the sample size were commercial saloon cars. 24 respondents corresponding to 24% of the sample size were private saloon cars. 1% of the sample size was an LPG powered commercial truck. The greater percentage (75%) of LPG users was skewed towards commercial saloon cars (taxis).

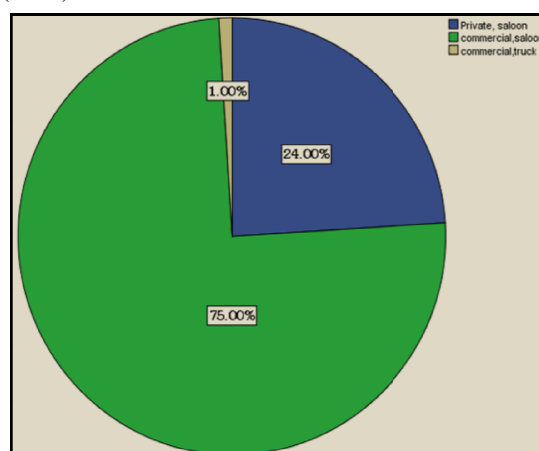


Fig. 4.1 Types of LPG Powered Vehicles in Tema Community One

4.3 Reason for Using LPG

Fig 4.2 shows the percentages corresponding to the reasons for using LPG as fuel by the respondents. 60% of the respondents stated that, LPG is cheaper whereas 40% of the respondents stated that LPG is more efficient, covering more mileage at a lower cost (Liu *et al.*, 1997). The majority of the respondents (60%) at every taxi station visited stated that the reason for converting to LPG was because LPG was comparatively cheaper with 40% asserting that it was because LPG was comparatively more efficient giving them much profit in daily sales.

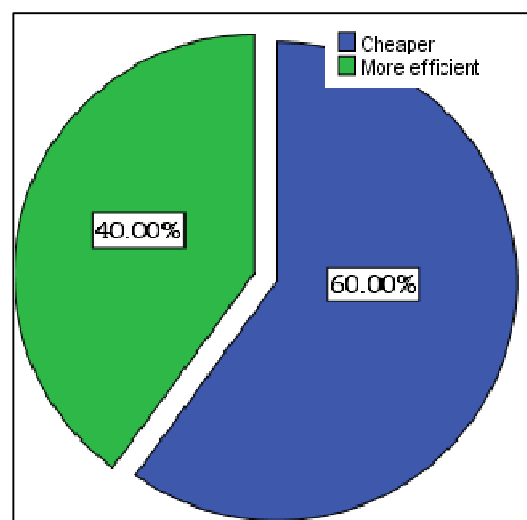


Fig. 4.2 Reason for Using LPG

4.4 Conversion

Presented in Fig 4.3 is the result of the assessment of the spate of conversion compared with whether the vehicles assessed, where originally manufactured to run on LPG. The majority of the respondents converted their vehicles from other fuel engines to LPG. The respondents who converted correspond to 81% of the total sample size. 19% of the respondents drove cars originally manufactured to run on LPG.

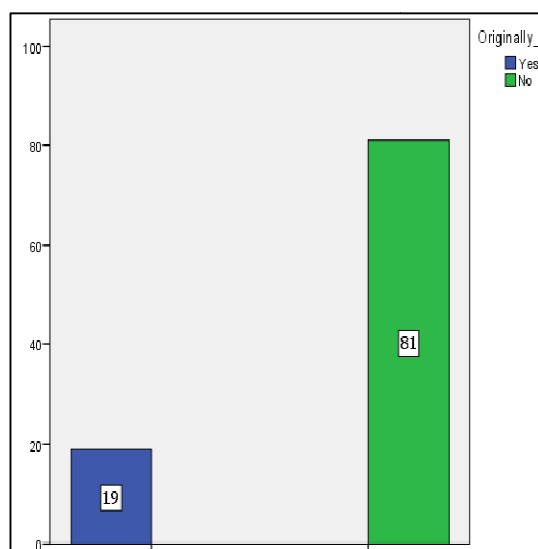


Fig. 4.3 LPG Converted Vehicles versus originally run LPG Vehicles

4.5 Origin of Cylinder

Fig 4.4 shows the place of manufacture and name of the cylinders or LPG bottles used in the LPG powered vehicles. Although conversion is done locally, imported LPG bottles are used. From the survey, there is a huge preference for Italian bottles which are widely acclaimed by the respondents to be durable than the other LPG bottles. 44% of the respondents used imported Italian LPG bottles. The Korean LPG bottles follow closely with a percentage of 30%, although Korean LPG bottles are comparatively cheaper (Tetteh et al., 2014). The Chinese and German bottles come in third and fourth places respectively with a usage percentage of 7% and 6% respectively. The Ghanaian bottles are now penetrating the LPG bottle market and are the least considered by prospective LPG powered vehicle operators (Anon, 2014). Ghanaian bottles come in the fifth place also attracting a usage percentage of 4%. 3% of the respondents apiece used the American and uncertain origin bottles respectively. 2% used the Dutch bottle. Fig 4.5 shows an imported Korean and Ghanaian bottles used by commercial vehicles.

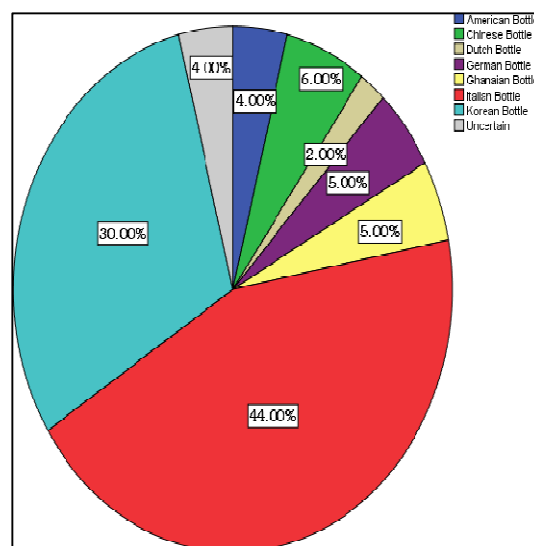


Fig. 4.4 Origin and Name of LPG Bottles



Fig. 4.5a Imported Korean Bottle

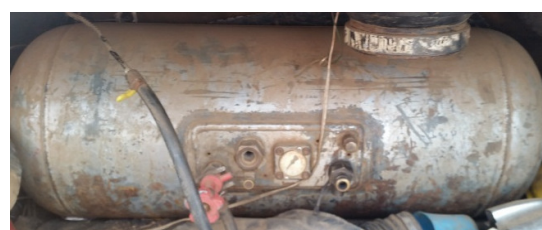


Fig. 4.6b Ghanaian Bottle

4.6 Volume of LPG Bottles Used

The choice of cylinder volume varies widely as shown in Fig. 4.6. The majority of the respondents use the 80 litre (l) LPG gas bottle. The sporadic shortages that tend to hit LPG fuel, influenced their choice of the 80 l gas bottle. It was observed that LPG bottles of volumes 80 l, 70 l, 60 l and 55 l were the most used amongst the respondents. A total of 37%

used the 80 l bottle, followed by the 60 l and 55 l. The fourth most used LPG bottle was the 70 l (17%). The 75 l and 45 l placed fifth and sixth with 4% apiece. The 85 l had a usage percentage of 2% placing seventh in the pecking order. The 50 l bottle was the most sparsely used with a usage percentage of 1.

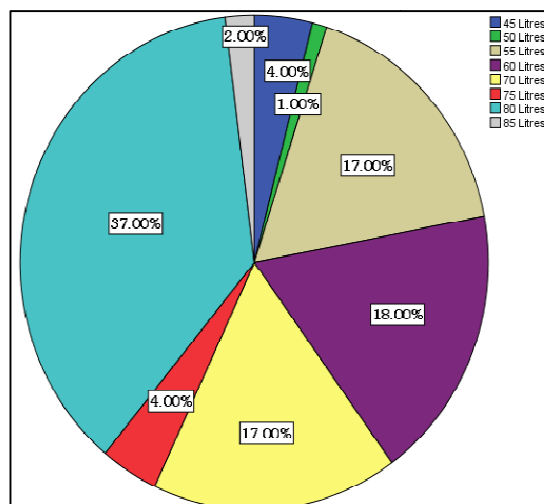


Fig. 4.7 Volumes of LPG Bottles Used

4.7 Expiration of LPG Bottles and Pipes

Unconventionally, drivers interviewed seldom knew the expiry date and pressure ratings of their LPG bottles and LPG pipes. Majority of the respondents (98%) asserted that, the only time they replaced their cylinders was when the cylinders were extensively damaged beyond galvanizing and welding. Contrary to the view held by respondents that cylinders do not have expiry dates, cylinders just like other products have expiry dates. The life spans of cylinders are between 10 to 20 years after manufacture. LPG bottles imported into the LPG bottle market are usually either halfway or even fully exhausted their lifespan. Fig. 4.7 shows the phenomena.

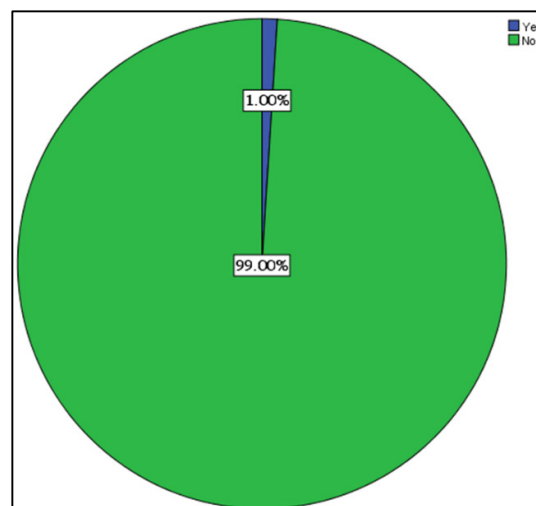


Fig. 4.8 Knowledge on date of Expiration of Bottles

4.8 Types of LPG Pipes Used

The types of LPG pipes often used in LPG conversion are either fridge or brake pipes. The fridge pipes are relatively more flexible and cheaper than the brake pipes. The brake pipes on the other are comparatively more robust and durable. The robustness and durability of brake pipes have made them the preferred choice of pipes for connecting the LPG bottles to the vehicle engines. Fig. 4.8 shows fridge pipe type of LPG pipes used. The number of respondents that stated they used the brake pipes were 53% while 33% used the fridge pipes. 14% were uncertain about the type of pipes they used.

4.9 LPG Usage Challenges

The challenges often encountered with respect to LPG usage ranges from shortages, to price hikes. The uneven price fluctuation of LPG was earmarked as the main challenge with the shortages coming second. 58% of the respondents asserted that they encountered some challenges like competitive pricing, availability of refuelling stations and leakage spot identification. On the other hand 42% of the respondents asserted that the challenges faced are sporadic shortages and availability of conversion and repair centres.



Fig. 4.9 Fridge Pipe

4.10 LPG Safety Knowledge

Majority of the respondents (57%) revealed that they had some rather general safety knowledge about the usage of LPG in their vehicles. The type of safety knowledge exhibited by the respondents was from their experience of using LPG powered vehicles which are not very much reliable. They had not received any formal standard safety training about LPG usage. Fortunately, all the respondents have not encountered fire or explosion since they converted to LPG. The following safety knowledge were revealed during the survey:

- i. LPG from the cylinder to the engine is disconnected when a leakage is detected.
- ii. Fire extinguisher and dampened duster are kept when working
- iii. Naked wires near cylinders are coated.
- iv. Leakages are immediately rectified.

43% of the respondents revealed that they did not have any standard safety knowledge about the LPG usage in vehicles. The volatile nature of LPG requires knowledge about the standard safety codes. Evidently, the percentage of respondents who did not have any safety knowledge raises a cause for concern. It was observed that not a single respondent had knowledge of the pressure ratings of either the cylinders or tubes.

4.11 Leakage Detection and Rectification

Leakage detection techniques include: odour or smell; drop in fuel gauge; gushing sound; and use of a sensor.

Surprisingly, all the respondents stated that, the leakage detection technique they utilise is the use of smell. The use of smell as a leakage detection technique is not reliable because strong winds can disperse the smell and the leak will go undetected. A prospective LPG vehicle driver who lacks the use of his or her sense of smell is most likely to experience unnoticed leakages. Should leakages go unnoticed, and not readily rectified, fatal fire explosions may happen leading to loss of lives and property. Again, atmospheric inversion may give an incorrect location of leak. The spate of conversion has necessitated the need for rapid and reliable leakage detection techniques. The integration of good quality instruments with advanced real time models built on instrumentation will eliminate the unreliable method of the usage of smell. 91% of respondents rectify leakages by consulting LPG vehicle specialist mechanics whereas a 9% rectified leakages on their own.

5.1 Conclusion

The following conclusions were made from the research:

- i. The majority (81%) of LPG powered vehicles in the Tema Community 1 metropolis were converted from an original gasoline fuel engine. The main reason for the usage of LPG in vehicles is for economical purposes (60%) and not for environmental purposes as backed by regulation in many developed countries.
- ii. The LPG bottles or cylinders widely used for LPG conversion are the imported cylinders (97%) of which Italian LPG bottles dominate with a percentage of 44%.
- iii. LPG vehicle drivers (98%) do not have knowledge of the expiration of the LPG bottles and LPG pipes used in their vehicles. Also, the LPG bottles and LPG pipes are not regularly maintained unless they are extensively damaged beyond repairs. In furtherance of the above, LPG vehicle drivers (57%) have limited knowledge

- of standard safety codes to be observed in the usage of LPG.
- iv. The only method for leakage detection employed by most LPG vehicle drivers is by the use of smell which is unreliable in windy environments and often affected by atmospheric inversion. The detergent solution application method of leakage spot identification is the only method for confirming spots of leakages.
 - v. The LPG vehicle drivers have no knowledge of the pressure ratings of their cylinders and tubes but resort to non-professional mechanics or LPG mechanics to rectify leakages and LPG conversion system faults.

5.2 Recommendation

The following are the recommendations made:

- i. The government should strengthen and enforce existing legislations and standards that govern the LPG market and assure both the public and consumer safety.
- ii. The DVLA should seek private sector participation to establish regulatory bodies to regulate the conversion of vehicles to LPG fuel.
- iii. Conversion of vehicles should only be done by certified garages who should prove their competence and expertise prior to being awarded a license to carry out LPG conversions.
- iv. The Driver Vehicle and Licensing Company should partner with Non-Governmental Organisations (NGO's) to provide formal training for LPG mechanics and drivers so that they would be abreast with current trends in the autogas industry and apply them.
- v. LPG powered vehicles should be inspected at regular intervals to ascertain the reliability and efficiency of the vehicles.
- vi. An LPG safety device should be installed in all LPG powered vehicles to for safety purposes.
- vii. Furthur Research should be conducted to ascertain the expiry dates of the tubes and cylinders used for the conversions.

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