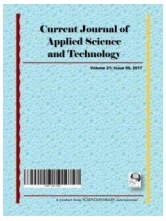

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The Use of Liquefied Petroleum Gas (LPG) as a Fuel for Commercial Vehicles in Ghana: A Case Study at Tema Community 1

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Authors' contributions

This work was carried out in collaboration between all authors. Authors RA and EBB designed the study, performed the statistical analysis, wrote the protocol and first draft of the manuscript. Authors DW and SAK managed the analyses of the study and the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Globally, there is an increasing number of vehicles being manufactured to run on LPG due to its tendency to decrease exhaust emissions and also increase profit for vehicles users; endearing many commercial drivers. The commonest means of transportation in the Tema metropolis, Ghana, is by commercial taxis. It is estimated that about 1600 commercial vehicles (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 body in Ghana (Driver Vehicle and Licensing Authority) has 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

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looks into the use of Liquefied Petroleum Gas (LPG) as a fuel for commercial vehicles in Ghana, using Tema Community 1 as a case study. Questionnaires were distributed to 100 out of estimated 160 LPG powered vehicle users to sample their views on the use of LPG to fuel vehicles. It was revealed 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; a very unreliable and unsafe practice. The LPG automobile users show inadequate safety knowledge on LPG usage. It is recommended that government should establish by-laws to regulate the operations of all LPG automobile users, perform regular training, education, inspection and enforce all LPG automobile users install safety devices in their vehicles for safety purposes.

Keywords: Liquefied petroleum gas; safety; pipe; vehicle.

1. INTRODUCTION

Liquefied Petroleum Gas (LPG) describes flammable hydrocarbon gases including propane, butane and mixtures of these gases. It is a liquefied gas through pressurisation from natural gas processing and oil refining. LPG is found naturally in combination with other hydrocarbons, typically crude oil and natural gas. The typical 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. Propane is the most common type of fuel for internal combustion engines after petrol and diesel [1,2,3]. LPG and other NGLs are emerging as attractive alternative fuels for many applications including transportation due to their clean burning characteristics, very low amount of sulphur contents, lower exhaust pollutions, lower running costs, stricter air pollution regulations and emission controls compared to liquid petroleum fuels (petrol-driven and diesel-driven vehicles), especially in the case of heavy transports [1,2,3]. LPG reduces carbon dioxide emissions by 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 [4]. Globally there is an increasing number of vehicles being manufactured to run on LPG. Studies show that as of 2010, there were about 12.7 million natural gas vehicles worldwide [5]. LPG has many other uses. It is increasingly being used as an aerosol propellant and a refrigerant replacing chlorofluorocarbon in an effort to reduce damage to the ozone layer. It is also employed as a major feedstock for the petrochemical industry [4].

Though LPG has many benefits, it is also associated with high safety and environmental issues when not handled well. It can cause explosions, burns, health-related issues and deaths. It is therefore mandatory that users of this LPG be well trained or educated in the safe handling of the product [6,7,8]. This study, therefore, seeks to investigate how commercial drivers in Tema Community 1 handle LPG in their vehicles.

2. LITERATURE REVIEW

2.1 LPG-Powered Commercial Vehicles in Tema Community 1

A research conducted by Energy Commission (EC) of Ghana in 2011 revealed that about 37% of LPG supply to Ghanaian market is consumed by the transport sector (vehicles) while the remaining 63% is consumed by households and other sectors [9]. The Tema East, Tema South, Tema West and Tema North form the Tema Metropolis. There are twenty-six (26) communities in the metropolis; the most popular and busiest communities are Communities 1, 2, 4, 7, 8, 9, 13, 18,19 and 20 [10]. The commonest means of transportation in the Tema metropolis is by commercial buses and taxis but the taxis are the main vehicles being used within the city of Tema. It is estimated that about 1 600 commercial vehicles (taxis) actively run in the metropolis (averagely, about 160 taxis in each most popular and busiest communities). Out of this total taxi running in the metropolis, about 1 200 taxis (75%) actively run on LPG [10]. 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 occupants of these vehicles and possible passers-by [11,12].

The importance of safety knowledge of LPG powered vehicle users cannot be overlooked as it will enable the Driver and Vehicle Licensing Authority (DVLA) and other regulatory bodies to exercise regulatory authority over the conversion of liquid petroleum fuels vehicles to LPG operated vehicles. In this regard, the Government/DVLA can enact by-laws to govern the conversion and operations of these vehicles within the country.

2.2 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 with certification [13]. Although this practice is on the increase with a lot of vehicle owners opting for this; taxi owners' are faced with 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 this could easily lead to a system failure; affecting the performance of the vehicle [11]. Unfortunately, most vehicles owners are not aware of these challenges at the initial stages until the engines of such vehicles finally break down. Though LPG or autogas is considered widely as a green fuel, it is also associated with high safety rick including fatal fire explosions, dizziness and cardio-respiratory arrests and deaths upon exposures [1,3,5]. There are therefore regulations that ensure regular inspection of LPG vehicles as well as proper training of personnel handling LPG for safety reasons in most countries [3,6,7] but unfortunately, such regulations do not exist in Ghana.

The beginning of the LPG Promotion Programme in the 1990s programme in Ghana saw extensive promotional and educational campaigns carried out to ensure that environmental, health and safety regulations in the domestic sector were observed [14]. But lack of continual education on the proper handling of LPG has resulted in series of accidents across the sector. Between 2007 and 2015, about ninety-six (96) persons died while 486 sustained various degrees of injuries in only 19 reported cases involving LPG explosions [15]. Out of the 19 cases, 9 involved industrial settings (gas stations, fuel stations and fuel dump), while 6 were gas tanker crashes, with the remaining 4 being domestic accidents.

A research conducted by Broni-Bediako et al. [16] revealed lack of safety knowledge of LPG domestic users in Tarkwa, majority of users lacking the basic safety procedures when connecting fully-filled cylinder to LPG appliance, detecting leaks, *etc*. The research also revealed that majority of the domestic users have no idea on how to detect leaks with high percentage using a matchstick to detect LPG leaks; which is a very dangerous practice as far as LPG handling is concerned.

2.3 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 [6,17]. Removal of component parts like gas motor and cylinder for servicing should be only done by trained personnel. A comprehensive set of rules concerning the safe handling in accordance with government regulations must be strictly adhered to [6,7]. Unfortunately, most handlers of LPG in Ghana lack such safety guidelines.

3. MATERIALS AND METHODS

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. 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 [18]. 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 [19]. Both primary and secondary

data were employed in this study. Primary data was obtained from the LPG powered vehicle users in Tema Community 1 whereas secondary data was obtained from existing work published in this study, media reports and Ghana National Fire Service documents. Both qualitative and quantitative analysis was employed in this study. The data were categorised and tabulated to address the purpose of the study.

4. RESULTS AND DISCUSSION

Information gathered included perspectives of the various LPG powered vehicle users with reference to the choice of LPG as a fuel, place of manufacture of the cylinder, a period of usage, types of pipes, the expiry date of pipes and cylinders, pressure rating, the capacity of cylinders, safety knowledge, leakage detection *etc.* The responses from 100 LPG automobile users in Tema Community 1 are presented thereafter.

4.1 LPG Automotive Vehicle Types

The vehicle types that were assessed for the purpose of the research work are presented in Fig. 1. The commercial business district of Tema metropolis; Community 1, is the hub of many businesses, as a result, 75% of the sampled LPG powered vehicles were commercial saloon cars (taxi), 24% being private saloon cars and 1% were LPG powered commercial truck.

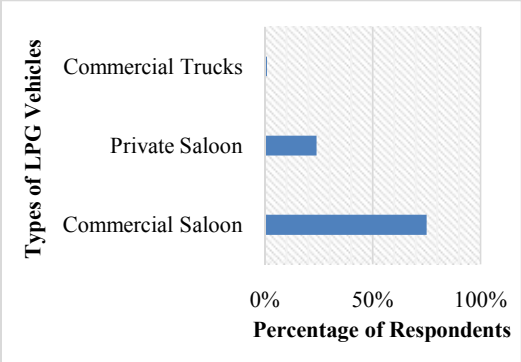

Fig. 1. Types of LPG Powered Vehicles in Tema Community 1

4.2 Reason for Using LPG

Fig. 2 shows the percentages corresponding to the reasons for using LPG as fuel by the respondents. 60% of the respondents were of the opinion that, LPG is comparatively cheaper whereas 40% of the respondents stated that LPG is more efficient, covering more mileage at a lower cost.

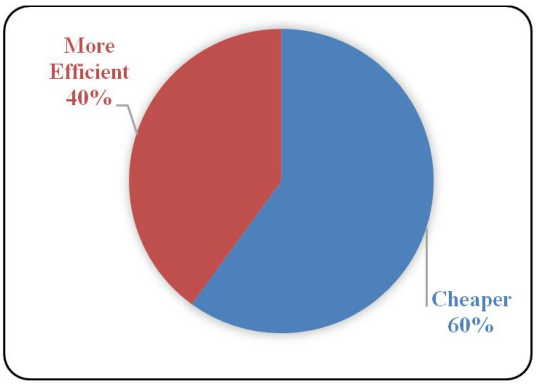

Fig. 2. Reason for using LPG

4.3 LPG Automobile Conversion

Fig. 3 presents the result of the assessment of the spate of conversion compared with whether the vehicles assessed, were originally manufactured to run on LPG.

The majority (81%) of the respondents converted their vehicles from other fuel engines to LPG while only 19% of the respondents drove cars originally manufactured to run on LPG.

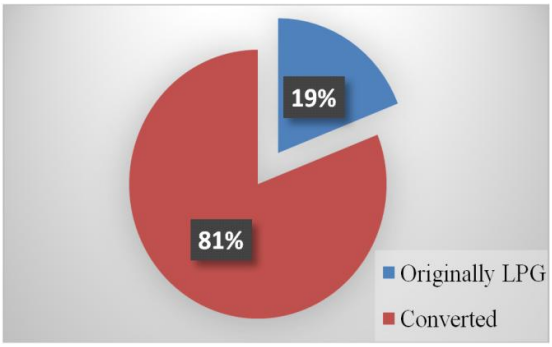

Fig. 3. LPG converted vehicles versus originally run LPG Vehicles

4.4 Origin of Cylinder

Fig. 4 shows the place of manufacture and name of the cylinders or LPG bottles used in the LPG powered vehicles.

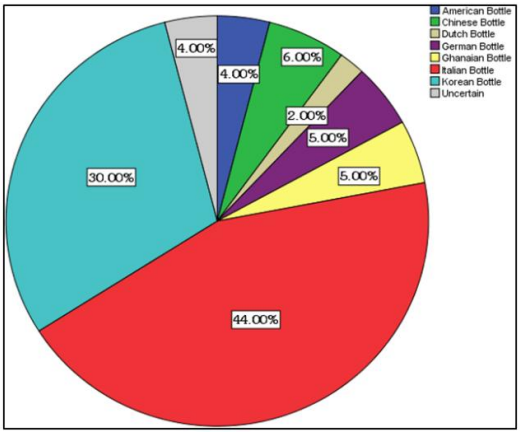

Fig. 4. Origin and name of LPG bottles

From the survey, the imported LPG bottles dominate the market (95%). There is a huge preference for Italian bottles (44%) which are widely acclaimed by the respondents to be durable than the other LPG bottles, followed by the Korean LPG bottles (30%). The Chinese bottles come in third with 6% of the respondents having it installed in their vehicles. The Ghanaian and German bottles placed fourth with 5% each. 4% of the respondents apiece used the American and uncertain/unknown origin bottles. 2% used the Dutch bottle. Figs. 5 and 6 show an imported Korean and Ghanaian bottles used by commercial vehicles.

Fig. 5. Imported Korean bottle

Fig. 6. Ghanaian bottle

4.5 The volume of LPG Bottles Used

The choice of cylinder volume varies widely as shown in Fig. 7.

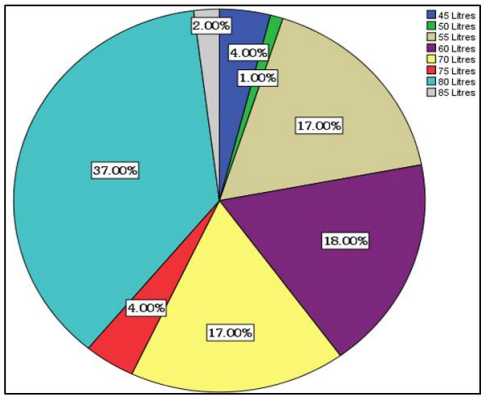

Fig. 7. Volumes of LPG Bottles Used

The majority (37%) of the respondents use the 80-litre (l) LPG gas bottle because of its availability and high storage purposes. A total of 18% of the respondents used 60 litre bottle followed by 55-litre and 70-litre bottles (17%). The 75 and 45-litre bottles placed fifth and sixth with 4% apiece. The 85-litre bottle had a usage percentage of 2% placing seventh in the pecking order. The 50-litre bottle was the most sparsely used with a usage of 1%.

4.6 Types of LPG Pipes Used

The types of LPG pipes often used in LPG conversion are either low pressure (*fridge)* or high pressure (*brake)* pipes. The low-pressure pipes are relatively more flexible and cheaper than the brake pipes. The high-pressure pipes are comparatively more robust and durable. The robustness and durability of high-pressure pipes have made them the preferred choice of pipes for connecting the LPG bottles to the vehicle engines. Figs. 8 and 9 show low pressure and high-pressure pipe types respectively used. 53% of respondents use the high-pressure pipe while 33% use the low-pressure pipe. 14% were uncertain about the type of pipes installed in their vehicles.

Fig. 8. Low pressure pipe

Fig. 9. High pressure pipe

4.7 LPG Safety Knowledge

Majority of the respondents (57%) revealed that they have basic safety knowledge about the usage of LPG in their vehicles. This safety knowledge was gained from the experience of using LPG powered vehicles. Fortunately, all the respondents have not encountered fire or explosion since they converted to LPG. The following safety observations were made during the survey:

i. LPG pipes from cylinders to the car engines are disconnected manually when a leakage is detected.
ii. Fire extinguisher and dampened duster are kept when working;
iii. Exposed wires near cylinders are always coated.
iv. Leakages are immediately rectified.

43% of the respondents revealed that they did not have any safety knowledge about LPG usage in vehicles. Evidently, all the respondents have not had any basic safety training or education on the handling of LPG, therefore, raising safety concerns. It was observed that none of the respondents had knowledge of the pressure ratings of either the cylinders or pipes/tubes installed in their cars.

4.7.1 Expiration of LPG bottles and pipes

Unconventionally, drivers interviewed seldom knew the expiry date and pressure ratings of their LPG bottles and LPG pipes (Fig 10). Majority of the respondents (98%) asserted that the only time they replaced their cylinders were 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 estimated to be 15 years after manufacture [20]. It has been established that most of the LPG bottles imported into the country are usually either halfway or even fully exhausted their lifespan. Therefore, as at July 2001, Export and Import Act, 1995 (ACT 503) of Ghana, prohibited the importation of used LPG cylinders but unfortunately, this has not been adhered to [21].

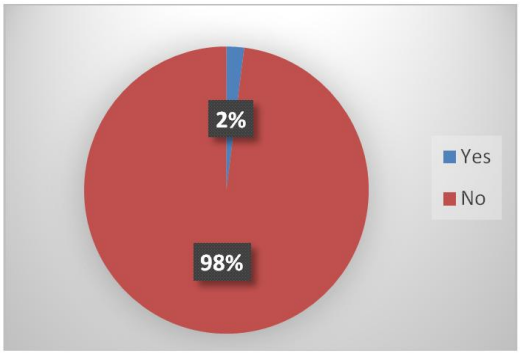

Fig. 10. Knowledge on date of expiration of bottles

4.7.2 Leakage detection and rectification

LPG leakage detection techniques include smell, drop in fuel gauge, gushing sound and use of sensors; the latter being the most reliable (sensitive enough to set off even with a slightest trace of LPG in the air) to avert major disasters [6].

Alarmingly, all the respondents stated that the leakage detection technique they utilise is by the use of smell. The use of smell as a leakage detection technique is not very reliable and safe because strong winds can disperse the smell and the leak 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 therefore not readily rectified, fatal fire explosions may occur leading to loss of lives and property. Again, atmospheric inversion may give an incorrect location of the leak. The spate of conversion has necessitated the need for rapid and reliable leakage detection techniques such as the use of LPG leakage sensor. But conventionally, when a leak is suspected in the vehicles, detergent solution is applied along LPG pipes/tubes for leak-spot identification. A practice that promotes continues release of the explosive gas into the air. 91% of respondents rectify leakages by consulting mechanics whereas 9% rectify leakages by their own efforts or alterations.

4.8 Challenges of Using LPG as Fuel in Vehicles

In spite of the benefit for using LPG fuel in vehicles, there are also challenges that drivers face in using LPG. In other to know the challenges, group interview was organised. The following challenges were revealed: competitive pricing, sporadic shortage of LPG, lack of LPG conversion and repair centres, and refuelling stations. 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, unavailability of refuelling stations and lack of leakage spot identification gadgets. 42% of the respondents asserted that the challenges faced are sporadic shortages and unavailability of conversion and repair centres.

5. CONCLUSIONS

The following conclusions are therefore made from the research:

i. The majority (81%) of LPG powered vehicles in the Tema Community 1 were converted from original gasoline fuel engines. The main reason for the usage of LPG in vehicles is for economic 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 (95%) of which Italian LPG bottles dominate with a percentage of 44%.

iii. LPG automobile 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.

iv. LPG vehicle drivers have no official education or training on the safe handling of LPG.

v. Smell is the only technique used to predict the possibility of leakage followed by detergent solution application method for spot identification.

vi. LPG automobile drivers resort to non-professional LPG mechanics to rectify leakages and LPG conversion system faults.

6. RECOMMENDATIONS

The following are the recommendations made from the studies:

i. The government should establish by-laws to regulate the conversion of vehicles to run on LPG fuel. Thus, conversion of vehicles should only be done by certified garages or mechanics or only originally manufactured LPG powered vehicles should be allowed to run on LPG to protect both the public and consumer from LPG related disasters.

ii. LPG automobile drives should be given training or education on safe handling of LPG in their vehicles.

iii. LPG powered vehicles should be inspected at regular intervals to ascertain their safety, reliability and efficiency.

iv. LPG safety device (sensor) should be installed in all LPG powered vehicles for safety purposes.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dorosz P, Wojcieszak P, Malecha Z. Exergetic analysis, optimization and comparison of LNG cold exergy recovery systems for transportation. Entropy. 2018;20(59):1-18.
2. Parmar C, Bothra P, Deshmukh S, Arun AS, Sethuramalingam T. CNG leak detection, diagnosis and fault auto healing on small bi-fuel vehicle. 2016;1-12. Available:http://www.cmc-congress.com/papers/session3/Paper_SiddharthDeshmukh_CMC-India-2016_CNG_gas_leak_detection_20160502.docx
Accessd: May 10, 2018.
3. Liu E, Yue SY, Lee JA. Study on LPG as a fuel for vehicles. Research and Library Services Division, Hong Kong. 1997;30.
4. Tyler D. Use of LPG as transport fuel, Philippine daily inquirer; 2010. Avaiable:http://opinion.inquirer.net/17263/use-of-lpg-as-transport-fuel
(Accessed: March 18, 2014)

5. Anon society of automotive engineers. Hydrocarbon Refrigerant Bulletin; 2010. Avaiable:http://www.sae.org/news/releases/05hydrocarbon_warning.html (Accessed: February 6, 2017)
6. Anon. LPG and General Safety; 2011. Avaiable:http://www.lpg.in/category/general-safety (Accessed: May 15, 2018)
7. Tyler D. Guidelines for good safety practices in the LPG industry, world LPG Association (WLPGA), United Nations Environment Programme (UNEP). 2015; 64.
8. Tarim M. Evaluation of burn injuries related to liquefied petroleum gas. Journal of Burns and Care Research; 2014. Avaiable:https://www.ncbi.nlm.nih.gov/pubmed/23799481 (Accessed: May 25, 2018)
9. Edjekumhene I. LPG in Ghana: From crisis to 50% access – A Public Policy. Analyst's Perspective. Presentation Delivered at TEC LPG Seminar Series. 2011;44.
10. Anon. Tema Metropolis District; 2018. Avaiable:https://en.wikipedia.org/wiki/Tema_Metropolis_District (Accessed: May 15, 2018)
11. Tettehfio EO, Apreko AA, Bolu KB, Amoakohene SK. Assessing the effect of liquefied petroleum gas (LPG) car conversion systems in petrol car by local artisans in Ghana. Journal of Energy Technologies and Policy. 2014;4(4):1-9.
12. Anon. Disadvantages of LPG uses; 2018. Avaiable:http://www.lpg.in/disadvanta ges-of-lpg-uses.html (Accessed: February 18, 2017)
13. Anon. The pros and cons of autogas systems; 2012. Avaiable:http://gazeo.com/up-to-date/news/2012/The-pros-and-cons-of-autogas-systems,news,6603.html (Accessed: May 21, 2018)
14. Anon. Liquefied petroleum gas (LPG)-Substitution for wood fuel in Ghana - Opportunities and Challenges; 2004. Avaiable:http://wwwenergyaccess.wikispaces.com (Accessed: February 12, 2014)
15. Anon. Gas explosion between 2007-2015; 2016. Avaiable:http://www.todaygh.com/96-died-486-injured-in-gas-explosions-between-2007-and-2015/ (Accessed: October 6, 2016)
16. Broni-Bediako E, Amorin R, Koomson-Awortwe S. Safety knowledge of domestic liquefied petroleum gas (LPG) users in Ghana – A Case Study. Journal of Petroleum and Coal. 2017;59(1):54-61.
17. Anon. Liquefied Petroleum Gas; 2013. Avaiable:http://en.wikipedia.org/wiki/Liquefied-petroleumgas (Accessed: February 12, 2017)
18. Yin RK. Case study research: Design and methods, sage, thousand oaks, California. 2003;173.
19. Ghauri P, Gronhaug K. Research methods in business studies: A practical guide, pearson education limited, England. 2000;323.
20. Anon. Hydro-Testing of SCBA Cylinders; 2012. Avaiable:http://www.safteng.net/index.php/component/content/article?id=2129&itemid=4 (Accessed: May 15, 2018)
21. Anon. GSA calls for strict enforcement of legislation on second hand goods; 2018. Avaiable:https://www.gsa.gov.gh/2018/01/gsa-calls-for-strict-enforcement-of-legislation-on-second-hand-goods/ (Accessed: May 21, 2018)

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