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RESEARCH ARTICLE

LIQUEFIED PETROLEUM GAS (LPG) TRANSPORTATION AND STORAGE IN GHANA: THE SAFETY PERSPECTIVE

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ABSTRACT

The recent discovery of oil and gas in commercial quantities and the subsequent extraction, coupled with a three decade old action plan on Liquefied petroleum gas (LPG) usage, has led to a significant rise in the use of the commodity in Ghana. However the transportation, storage and use of LPG in the country has been rocked with a number of safety challenges that has resulted in ten major reported explosions in the last five years leading to some 33 fatalities. In this work, the key issues militating against the safe transportation, storage and use of LPG in Ghana; over reliance on road transport as the sole means of transporting the commodity, lack of gas leak detectors at LPG stations, inadequate knowledge on the commodity by major industry players, unskilled labor and logistical constraints are brought to the fore. Administrative control measures including; stringent rules on LPG transportation and storage, effective supervision to ensure appropriate safety gadgets are installed at LPG stations and advocacy on the part of the regulator are among the feasible hierarchy of accident control measures, to arrest the identified hazards with the sector in Ghana.

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INTRODUCTION

Liquefied petroleum gas (LPG) is an important gas product of petroleum refining primarily consisting of a mixture of the light hydrocarbons propane and butane usually 40% propane and 60% butane. It exist in gaseous state under atmospheric ambient conditions but can be easily converted to the liquid state under conditions of moderate pressure at ambient temperature. It generally occurs as a colorless odorless gas and hence to promote the safe use of the commodity commercially, it is customarily odorized with dimethyl sulfide (DMS) and tert butyl mercaptan (TBM) at a rate of about 10g of odorant per one cubic meter of LPG to facilitate easy gas leak detection (Seguel *et al.*, 2018; Raslavičius *et al.*, 2014). Liquefied petroleum gas is used as fuel for many residential, commercial and agricultural heat applications including; cooking, hot water systems and general heating purposes. In recent years, LPG is emerging as an attractive alternative fuel for many other applications including transportation due to their clean burning characteristics, relatively low exhaust pollution, low sulfur content, about 35% reduction in CO₂ gas emissions, low running cost, and strict air pollution regulations and emission controls compared to other liquid petroleum fuels such as petrol and diesel driven automobiles (Aggarwal *et al.*, 2018; Amorinet *et al.*, 2018). Liquefied petroleum gas is also employed as an aerosol propellant and a refrigerant to replace the noxious

ozone depleting chlorofluorocarbons (CFC's) and also as feedstock for the petrochemical industry (Hahn, 2018). Although there are seemingly enormous benefits associated with the use of LPG, it is worth noting that there are high safety and environmental issues associated with the transportation, storage and usage of the commodity that when not handled appropriately can have dire consequences on life and property. A typical example is the tragedy of San Juanico, Mexico in November 1984 in which an estimated 500 people lost their lives due to an LPG explosion (Arturson, 1987). Such tragedies are not limited to one geographic area, and Ghana for that reason, is no exception. Ghana, a developing country in West Africa with a population of about 29 million (2018 United Nations Estimates) in recent years, has faced challenges in terms of fuel safety in general (Worldometer, 2018). A number of catastrophic incidents have occurred in recent times though not on a grand scale like the Juanico tragedy, but equally raise concerns about safety and the need to address such challenges. Herein is a review of the liquefied petroleum gas industry in Ghana, the major safety challenges in the transportation and storage of the commodity that has frequently resulted in accidents and measures to put in place to ameliorate the situation.

Liquefied petroleum gas usage in Ghana: The government of Ghana, in its bid to curtail the rate of deforestation as a

result of increase in population and the concomitant dependence of the populace on biomass fuel, specifically firewood and charcoal in the 1980's, launched the National LPG Promotion Program (NLPGPP) in 1989 under the auspices of the Ministry of Energy (Asante, 2018). The program among other objectives, was to also reduce pollution and add value to the operations of Tema Oil Refinery (TOR) by eliminating the hitherto practice of flaring the LPG (Broni-Bediako and Amorin, 2018). As a result of this program and other successive interventions such as subsidies on the commodity to reduce the end user price, patronage of LPG has increased tremendously in the country from homes (for domestic purposes such as cooking), public institutions (schools and hospitals), and industries to private vehicles (for transportation purposes). Although significant gain was made in the use of LPG in general, the objective of expanding LPG access to 50% of Ghana's population by 2015 as set out in the NLPGPP was not met (Amuzuvi and Ashilevi, 2016). A major issue militating against smooth operations of the LPG industry in Ghana is the rampant occurrence of accidents in recent years.

Safety challenges confronting the lpg industry in Ghana:

Ghana has had its first share of accidents emanating from the LPG and its associated industry calling for pragmatic measures from industry players. Most of the challenges are obvious safety breaches which can be prevented or easily avoided. The transportation of hazardous materials such as LPG via pipeline is generally considered a safer alternative to other modalities for transportation such as rail, road or ship (Bubbico *et al.*, 2018). However in Ghana, with the exception of the transportation to the thermal plants for energy generation, LPG is solely transported by road from the refineries to LPG stations where the commodity is retailed to consumers for domestic purposes and in some cases for fueling vehicles. The associated risk in transporting the commodity from the refinery to other parts of the country by road cannot be overemphasized. A typical example is the near fatal accident that occurred on the Tema motorway on the 17th of January 2017, when a gas tanker carrying products worth 50000 kg of LPG en route Tema from Takoradi fell on the road. But for the timely intervention by personnel of the Ghana National Fire Service, a disaster of large magnitude could have occurred (Glover, 2017).

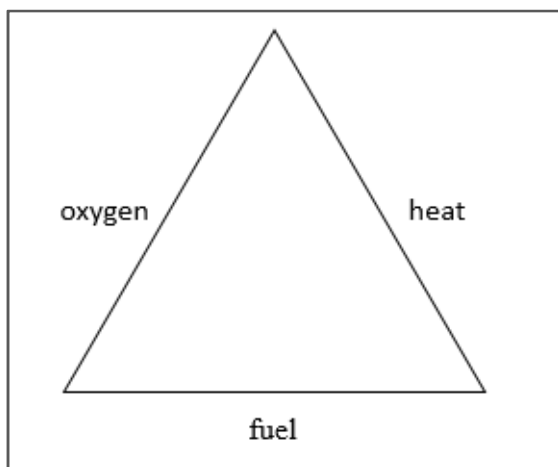


Figure 1. Fire triangle (Sriwati *et al.*, 2018)

LPG is highly inflammable and readily forms explosive air – vapor mixtures when leaked into the atmosphere. With oxygen

ever present in air, a source of fuel (LPG air – vapor mixture) available, the least available source of an ignition results in a conflagration and subsequent explosion in some cases, and hence, vehicles for transporting such a highly hazardous chemicals (due to its high flammability) need to install state of the art equipment to detect gas leakages easily and subsequently sound a warning for swift action to be taken before it degenerates (Amuzuvi and Ashilevi, 2016). Sadly, the reality is far from the ideal. In the current dispensation, LPG stations which serve as the vending and retail centers for the commodity are a major point of safety gap. The cylinders used for the bulk storage have in some instances been used for several years in other European countries, have been decommissioned but are brought and installed in stations in Ghana for the purposes of storage. Such bulk tanks are usually weak in terms of material strength but are being used on day to day bases for business purposes. Some of the storage tanks especially in the rural areas lack all the appropriate fittings as required by the National Petroleum Authority the regulatory body mandated to ensure the safety of the petroleum sector in Ghana. Many stations lack state of the art gas leak detection systems (sensors) to detect leaks beyond the threshold values so as to inform the appropriate bodies for prompt action to be taken on time (Amuzuvi and Ashilevi, 2016). Accurate means of LPG leak detection has therefore been renegaded to the background hence gas leak detection is basically limited to basic sensory test (scent detection with the nose). Compounding the problem is the fact that, most of the industry players especially, those involved with day to day contact with LPG, lack basic knowledge on the commodity. Most of the LPG filling station attendants have limited knowledge on the dangers inherent in their work and the emergency procedures to follow in an eventuality. Some entrepreneurs in the LPG business resort to employing unskilled labor including high school graduates who are need of temporal jobs hence are not given the necessary training to be fully competent to run such facilities. The obvious result are the breaches in safety protocols. The National Petroleum Authority, appears to be more interested in the ensuring compliance at the refineries and the LPG stations to the detriment of the end user of the product. There is apparently no standard operating procedure (SOP) on the use LPG for households. Domestic users and vehicle drivers who make up about 92% of LPG users in Ghana, are the least informed on the safe use of the commodity. In a recent survey in Ghana, 98% of respondents did not know this who use LPG as fuel do know the LPG bottles (cylinders) have expiry dates like any other product (Amorin *et al.*, 2018). The very few who know might probably not accurately deduce the expiry date. For instance an expiry date of 1/19 means the LPG bottle (cylinder) will expire in the first quarter (January to March) 2019. As a consequence of the enumerated challenges above, the LPG accident related issues in Ghana are on the rise. About Ninety- six (96) people lost their lives and 486 people sustained various degrees of injury between 2007 and 2015 as a result of LPG related accidents in only 19 reported cases (Broni-Bediako and Amorin, 2018). The situation is not different in recent years. In the last five years alone, ten (10) major LPG accidents have been recorded in Ghana.

Ameliorating the challenges in lpg transport, storage and use in Ghana: To successfully curb the increase in the LPG related accidents, one of the best theoretical approaches, as per the hierarchy of controls, is for the country to completely shun the use of the commodity (the hazard) (OSHA, 2018).

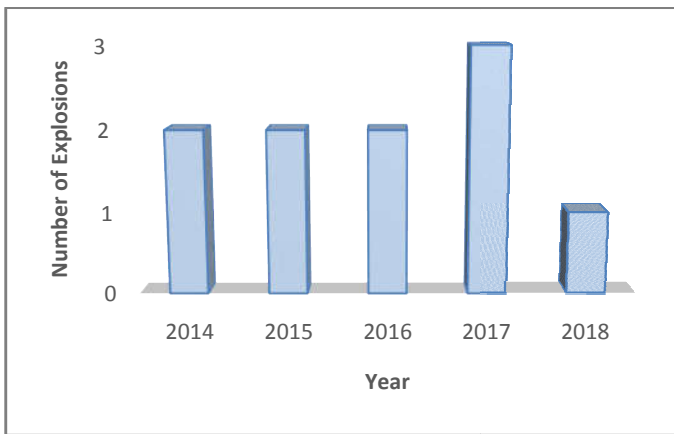


Figure 2. Number of LPG explosions per year for the past five years

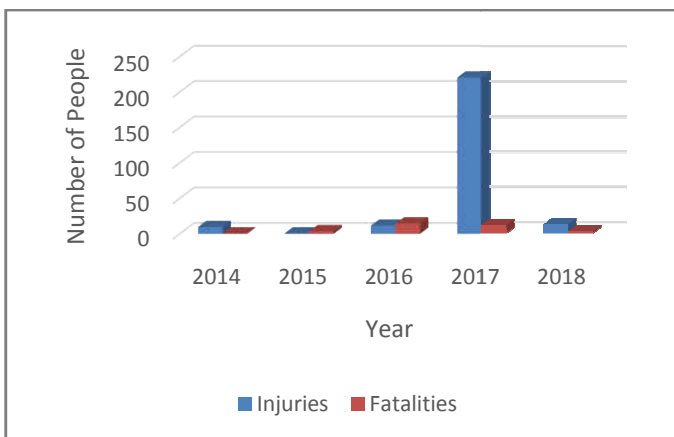


Figure 3. LPG Accident casualties (injuries and fatalities) per year

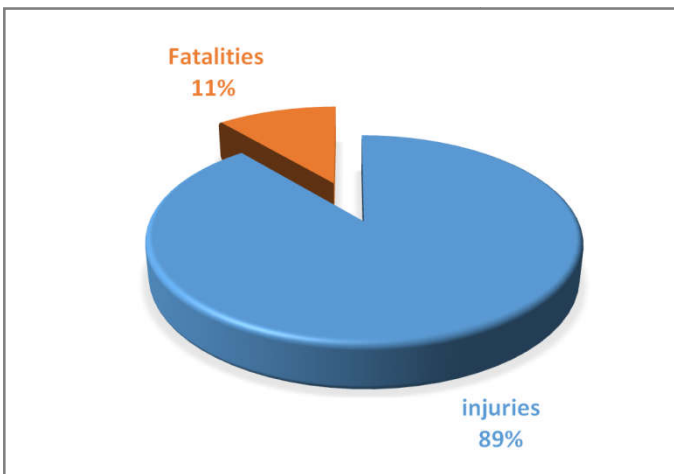


Figure 4. LPG Accident injuries and fatalities over five year period

DISCUSSION

However, this approach will not be economically prudent owing to the growing demand for LPG in Ghana and coupled with the fact that, Ghana has in recent times discovered oil and gas in commercial quantity and has subsequently started the drilling of oil and gas from the discovered fields. Furthermore, the investments the country has made already in the LPG subsector is enormous including the construction of a gas processing plant, Ghana gas company at Atuabo, near Takoradi in the western region of Ghana. The elimination of the use of LPG in Ghana will therefore not be a practically feasible means of addressing the high accident rates associated with the use of LPG in Ghana. The second most important

means of hazard control is substitution. Since LPG transportation in Ghana, is predominantly by trucks on roads, the authorities in Ghana can consider the introduction of LPG transportation via pipelines. This means of transportation is generally considered safer than transporting by road (Bubbico *et al.*, 2018). Moreover, Ghana is relatively safe with no record on terrorist activities and internal conflicts and hence the security issues usually involved in transportation of petroleum products via pipelines does not come to the fore. The government of Ghana should reconsider or review infrastructure policy or program such that subsequent residential developments would incorporate the provision of LPG pipelines (safely installed and monitored) into homes as in other western countries so that the risk associated with the movement of portable gas bottles or cylinders will be avoided. Engineering controls are next important and effective hazard control measures amongst the hierarchy of hazard controls. Though usually expensive than the other control measures, they are worth the cost when compared to the cost of accidents. The hazard is either isolated, enclosed, removed (or redirected) and in some cases a redesign of the workplace (OSHA, 2018).

The use of portable gas cylinders can be firmly secured (caged) in homes or when transporting them from one place to the other to prevent them (bottles) from toppling over and possibly exploding. Administrative controls, which involve changes to the routine way of executing a task are the next important hazard control measures. In the LPG transportation and storage safety issue at hand, most of the feasible solutions are under this segment. One of the surest ways of arresting the situation is for the government of Ghana through the industry regulator, the National Petroleum Authority to come out with stringent rules such that the transportation of LPG will be done solely in the night when the roads are less busy to minimize the number of people that will be exposed to the hazard. Vehicles used for transportation should have enough safety signage as well to warn other road users to be weary of the content. The National Petroleum Authority (NPA) should also have a rigorous training regime such that anybody who manages an LPG station will have undergone such a training to be fully competent to man the station. As part of the administrative control measures, the installation of LPG leak detectors should be made mandatory for all LPG stations as an early warning system (Amuzuvi and Ashilevi, 2016). Such a warning system can be synchronized onto a centralized platform with Ghana National Fire Service such that personnel are informed early so as to take the necessary measures in time to prevent catastrophes. There should be engagement with end users of LPG by the regulator through greater advocacy.

The proposed cylinder recirculation module to be implemented should be expedited (Asante *et al.*, 2018). This will afford an excellent for opportunity the industry regulator to come out with standard operating procedures (SOP) and make same available to end users of LPG. The cylinder circulation sites under the cylinder recirculation module should be adequately equipped to detect leaks and prevent the use of old cylinders (bottles) that have expired. Finally, the last resort in hazard control is the use of personal protective equipment (PPE). They are used when nothing can be done about the hazard. In the case at hand, the use of can only be effectively adopted by LPG filling station attendants. The necessary PPE's for their use will include; safety boots for foot protection, respirator (gas mask), to minimize the effect of inhaling the LPG as a

result of the long exposure hours. A reflective apparel (reflectors) should be worn by attendants especially during poor visibility.

Conclusion

Liquefied petroleum gas usage in Ghana is on the rise despite the challenges facing the industry especially the high spate of accidents in recent years. A number of measures can be taken to remedy the rampant explosions being experienced. Among the five hierarchy of control measures for curbing the occurrence of accidents, substitution, engineering control and administrative controls measures are feasible to be implemented to certain degrees to address the issue. The consideration of other means of transporting LPG by pipeline is a viable alternative (substitution among the hierarchy of controls). Engineering control methods such as securing LPG cylinders firmly in course of transport can be implemented. A combination of administrative control measures from specified times for transportation of LPG, to training of personnel at LPG stations, installation of leak detectors and cylinder recirculation module with its associated program additions will be most effective in arresting the canker.

Conflict of interest: The authors declare that there is no conflict of interest with regards the work.

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APPENDIX

Liquefied petroleum gas related accidents in Ghana

Year	Recorded Accidents	Locations	Casualties	Fatalities
2014	2	Nungua, Tema	11	1
2015	2	Kasoa, Dansoman	5	4
2016	2	Labadi, Bole	27	15
2017	3	Legon, Takoradi, Accra	232	11
2018	1	Kumasi	14	2

(Allotey and Clotley, 2017; Duodu and Gyesei, 2016; Frimpong, 2018)
