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Review Paper

Natural Gas Driven Vehicles Safety and Regulatory Regime – Challenges in Bangladesh

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ABSTRACT

Natural gas driven vehicles (NGV) is common in Bangladesh first introduced around 1995. Be that as it may, situation has changed because of minimal effort of CNG as fuel. The legislature additionally empowered the change of private vehicles by making a few strategy activities as Bangladesh has natural gas reserve, cost economy, low emission. Now passenger automobile like car, bus, and even agricultural vehicles are utilizing CNG as fuel. Faulty cylinders or other CNG-related kits in NGV not only endanger the lives of the passengers of the vehicles, but also of others somehow remaining close to the accident spots. The safety aspect of CNG runs vehicles are beyond regular and strict monitoring, even out of consideration. The objective of this paper is to find out the present scenario of the NGV of Bangladesh and safety perspective in compare to the CNG safety act of Bangladesh. For this purpose, other CNG safety standard of first world country along with exporter country is under consideration. This paper reviews the options available to policy makers in their efforts to reduce the causalities associated with NGV transport. It provides a summary of the categories of negative impacts targeted together with the specific policy initiatives available. The actions for regulation taken by policy makers and foregoing challenges are also underlined. To fight against the challenges a framework has proposed.

1 Introduction

A natural gas vehicle or NGV is an alternative fuel vehicle that uses compressed natural gas (CNG) or less commonly, liquefied natural gas (LNG) as a clean alternative to other automobile fuels [1, 2]. The on-board storage capacity of natural gas vehicles (NGVs) is a critical issue to the wide spread marketing of these alternate fuelled vehicles. In Bangladesh, CNG is used as a NGV fuel because of its availability and cheap rate [3, 4]. During last decade, the consumption of a CNG is increased almost 25% in share. By 2020 it is predicted to increase its energy share to 50% from the present of 22% [5]. Michiel Nijboer [6] concludes that natural gas can cover almost the whole spectrum of vehicles, ranging from motorcycles, tuk-tuks, cars, vans, buses, trucks, off-road vehicles, ships and trains, including even airplanes. Therefore, conversion of

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gasoline engine to NGV is increasing rapidly in both developing and developed countries [7]. This conversion will bring significant economic and environmental benefits of the country. It will reduce dependency on the imported fuels, increasing national security and lowering foreign trade deficit [8].

According to Jeewan V. Tirkey [9], NGV offers certain advantages such as clean combustion (no lead or sulphur compound) due to high H/C ratio, does not contaminate and dilute the engine oil which forms no deposits on spark plug. It also offers advantage over gasoline in terms of its low density and readily miscibility with air, high knock resistance (Octane number 120-130), lean burning capability. In present about 0.2 million CNG, driven vehicles are on service around Bangladesh including three-wheeler auto rickshaw, bus, private car etc. NGV safety strongly depends on design, materials, installation, operating conditions and maintenance. It is found that, all the vehicles have common system of CNG cylinder installation system that is quite dangerous, unacceptable from scientific view. Therefore, the problems during transportation are common like Figure 1. That endanger safer mode of journey with addition of sudden high cost repair. The drivers are mostly illiterate having no knowledge about the safety and danger. Wadud Zia [10] found that many fuel vehicles have converted as CNG driven without considering vehicles condition, road and equipment arrangement. In many case, local repairing shops do the work of conversion, whose have no knowledge about the safety. About 40% vehicles has no safety certified CNG cylinder, 17% locally converted as NGV. CNG is dispensed to an NGV through a process known as the fast fill process, since it is completed in less than five minutes. During fast fill, charging operations can occur under-filling of NGV cylinders. In the work of the C. Blake et al. [11], varies fuel standards and their customs has discussed.

Again the gas storing system, compressing and condensing system are defective at fuelling stations [12, 13]. Those faults introduce moisture in the cylinder causing reduction in service life. This paper focuses on the most common form of use of CNG that is NGV, safety of the NGV as transport vehicles. Again, the recommendation available to policy makers in their efforts to reduce the causalities associated with NGV transport is also discussed. Therefore, it provides a summary of the categories of negative impacts that can be targeted together with the reliable specific policy initiatives available to safer the operation of the NGV. An aim has made to identify weakness in vehicle codes and standards and to recommend actions that provide a means to fill these gaps. The actions for regulation taken by policy makers and foregoing challenges are underlined. A framework has proposed to fight against the challenges for NGV safety and regulatory regime.

2 Methodology of the study

The methodology of this survey is based on quantitative survey. The existence of basic components on the vehicles was observed in three sections. First, second and third section contained Essential, Safety, Optional parts respectively. During period of two months, three hundred NGV was covered at various locations including capital Dhaka, Bangladesh. We emphasized on CNG three-wheeler auto rickshaw, bus and private car, as it would reflect the true nature of the survey. Diesel vehicles have been excluded from this study because diesel automobiles engine are not being converted in this country yet.

Besides, a brief interview with several gas station owners was undertaken to have their ideas and suggestion. Interview of the drivers was taken on some related issue, which helped to do the discussion more specifically. It was required to go through various literatures to get information regarding the issue mostly supplied by RPGCL, BRTA, BERC, Department of Explosives, Ministry of Power Energy and Mineral Resource Division, daily newspaper and TV reports of Bangladesh.



Fig. 1- (a) Car with burned cylinder, (b) Porosity due to multi pass and over pressure

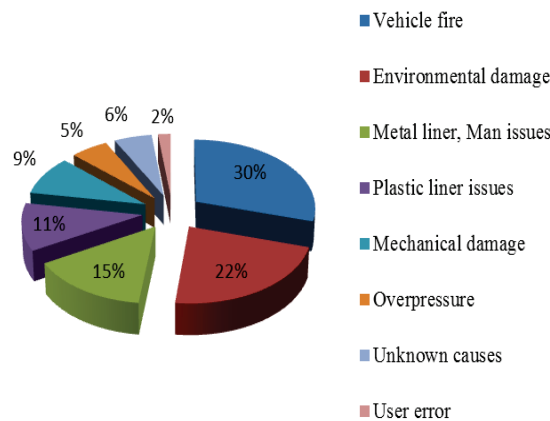


Fig. 2- Failure statistics

Table 1- Required safety components scenario

Safety items	Comment on observations
Pressure indicator or fuel level indicator	Yes
Pressure relief device	In some cases
Automatic cylinder valve	Yes
Manual valve	No
Pressure regulator	Yes
Gas flow adjuster	No/Inactive
Excess flow limiter	Yes but inactive
Filling unit or receptacle	Yes
Flexible fuel line	Yes
Electronic control unit	No
Temperature sensor	No
Fittings	Partially available

3 Summary of findings

The study astonishingly shows violation of NGV rule by drivers, owner including passenger also. One in ten NGV has no certified CNG cylinder; three in ten NGV has no safety fittings except pressure gauge, no training or technical support for the driver. Authority has no control over the situation. The identified problems are cylinder blast, leak, gas explosion, lack of monitory board and so on. Only 20% of convertible vehicles are running by CNG. NGVs have a shorter traveling distance compared to traditional fuels vehicle. Many in-built (dedicated) CNG busses have been damaged within short period. In-built dedicated CNG three-wheeler from Pakistan, China, and Thailand has already been damaged within short period. Only Bajaj three-wheeler from India is playing well. However, its lifetime is short compare to two-stroke Bajaj three-wheeler. Navana Ltd. and Nitol Motors Ltd. already stopped importing in-built (dedicated) CNG vehicles. Causalities associated with CNG vehicles are increasing day by bay. Figure 2 shows the causes of NGV failures. This causes are common phenomenon and quite familiar.

3.1 Cylinder failure

Common causes of CNG cylinder failure identified are due to the long cycles service, absent of valves, fittings, and/or pressure relief devices. Cylinders involved in collisions, fires due to smoking also contribute largely in cylinder failure. Chemical attack from on board passenger’s water bottle, lemon, cold drinks deteriorate the effect. There is always lack in-service inspection and periodic requalification. Use of sub- standard imported cylinder, improper installation as shown in Figure 3(a), 3(b) and 3(c) has found to have the similar effect. Even electric auto rickshaw is converted as gas driven vehicle as shown in Figure 3(d).

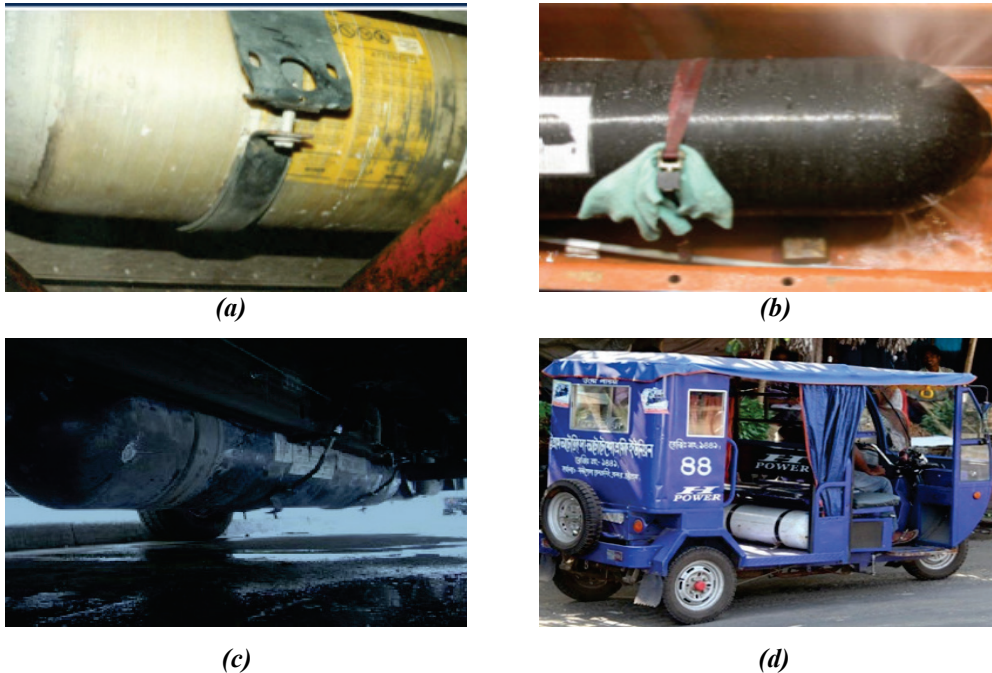


Fig. 3- (a) Cloth use for tightening the belt, (b) Improper nut-bolt setting, (c) Unprotected, protruding under floor cylinder mounting, (d) Electrically driven auto rickshaw locally converted as NGV



Fig. 4- (a) Residential building at the premise of filling station, (b) Long queue in filling station

3.2 Risks and hazards from NGV gas cylinders

Gas cylinders can be hazardous due to both their physical (size and weight) and chemical characteristics. The common reasons are fire or explosion from the release of flammable gases near ignition sources, incorrect storage, leaks, faulty equipment set up, physical risks, manual handling, sudden release of gas if cylinder is damaged, temperature rise of the cylinder etc. Table 1 shows safety components scenario of the NGVs running in the road.

3.3 NGV in enclosed parking

While a car parked, a gas release may occur due to a mechanical failure leading to a rupture, or a leak of the valve system of the NGV. A rupture may be caused by heat from a nearby car on fire or from a fire of smoking, spark. Therefore, safe parking place is an important factor to prevent blast.

3.4 Filling station

Slow fill installations can give rise to dangerous conditions specially when placed in enclosed garages. Maximum filling station has no safety phases to prevent firing from roadside smoking, even cooking arrangement, tea stall has found

established within the gas filling station ground. Many filling stations are at the side of residential building like Figure 4(a). Seventy percent filling station has no fire point and emergency contact number. They remain clog with long line of vehicle as in Figure 4(b).

Table 2- Statistics of CNG Filling Station and Conversion Workshop in Bangladesh

SI No.	Fiscal Year	No. of CNG Filling Station	No. of Conversion Workshop	No. Converted Vehicles
1	2014-2015	2	0	37368
2	2013-2014	0	0	6487
3	2012-2013	0	0	4382
4	2011-2012	0	0	5792
5	2010-2011	5	10	13343
6	2009-2010	119	29	28676
7	2008-2009	243	20	24516
8	2007-2008	85	13	22718
9	2006-2007	42	28	25974
10	2005-2006	23	31	26032

3.5 Facility problem

Facility problem is a major reason of CNG related accident. Table 2 shows the available conversion center in respect of the total converted vehicles for fiscal year 2005-2015 [14]. The date for year 2016 not included yet in the government data center. The common causes of accident relating facility are lack of authorized CNG conversion plant, policy and regulatory framework, and the lack of skill technician and training program. Unavailability of gas refill all over the country is promoting this. Many unauthorized conversion center and filling station are continuing their business by virtue of mismanagement, though they have no legal papers for environmental issue.

3.6 Safety acts and standards

NGVs are CNG fueled vehicles, thus discussed in CNG rules of Bangladesh. The rules are followed by the following sections (i) Safety Codes and Standard for CNG Fuel Systems for Vehicles- 2007 (Draft, Bangladesh Energy Regulatory Commission), (ii) Bangladesh CNG rules- 2005 (Department of Explosives; Energy and Mineral Resource Division; Ministry of Power Energy and Mineral Resources), (iii) The Liquefied Petroleum Gas (LPG) Rules- 2004, (iv) The Gas Pressure Vessel Rules- 1995, (v) The Natural Gas Safety Rules- 1991, and (vi) The Gas Cylinder Rules- 1991. The Gas Cylinder Rules regulate, import, filling, possession of manufactured cylinders, valves, safety fittings used for cylinders containing compressed gases viz., permanent gas, liquefiable gas or gas dissolved in liquid for toxic, flammable, non-toxic, non-flammable nature etc. Under the Gas Cylinder Rules, different type of licenses and different types of approvals are granted. The license is required for importing cylinders, filling of cylinders with compressed gases, for storage of filled cylinders for LPG bottling plants and CNG filling stations. Approvals are granted for manufacture of cylinders, valves, regulators and safety fittings etc. Conversion of gas cylinders from one gas service to another gas service, recognition of cylinder testing station, hot repairs of welded/brazed cylinders also requires approval under CNG rules [15]. Though all the laws were amended several times but those does not cover every aspect. The political intervention always influences the decision making team anyhow.

3.7 Overseas CNG cylinder standards

Bangladesh imports CNG cylinder from India, China, Korea, and USA mainly. Worldwide CNG cylinder standards are given in Table 3. Regular checking and retesting are clearly emphasized in international standard for CNG. In recent period Indian nonstandard cylinder are rapidly spreading because of its low cost and tax free illegal border entry.

3.8 Overview of CNG cylinder standards

Standards such as ISO 11439, ECE R110 and NGV2 2000 criteria are achieved by specifying service conditions of the vehicles and assessing the cyclic pressure fatigue life and establishing allowable defect sizes. This process must be

compliance with a set of design qualification tests like requiring non-destructive testing and inspection of all production cylinders and destructive tests on cylinders and cylinder material taken from each batch of cylinders produced. Furthermore, the requiring manufacturers to have a comprehensive quality system.

Table 3- Worldwide CNG cylinder standards [16, 17]

Supplier country	Standards	Comments
Germany, France, Italy, Slovakia, South Korea, Thailand, USA, Pakistan, India	ECER-110, ISO-110 ISO 11439, ANSI/CSA NGV 2	ISO 11439, ECE R110 and NGV2 require the cylinder manufacturer to provide recommendations on installation, use and periodic requalification for their CNG cylinders.

3.9 BRTA action for fitness of CNG vehicles

BRTA is the legalized government authority to investigate the vehicles fitness. However, BRTA is not inspecting the equipment and fittings of CNG portion of the vehicle. For CNG portion of the vehicle, BRTA is issuing the conversion certificate of the conversion center i.e. BRTA is taking only the conversion certificate during issuing/renewing the fitness certificate. Before issuing/renewing the fitness certificate of CNG vehicle, BRTA makes correction of the fuel type as CNG in registration certificate. According to government decision, correction of fuel type in the registration certificate is not a mandatory for the vehicle, which has been converted from Petrol/Octane engine to CNG driven engine. Correction is mandatory only for the vehicles, which has been converted from Diesel engine to CNG driven engine [18].

4 Challenges and Prevention

Unfortunately, the tendency to break or ignore laws is very high among the unconscious people. Some people indulge in the mischief deliberately and some others do it out of ignorance. However, the lack of solemnity on the part of the men in authority to enforce laws and punish the violators of the same has only been encouraging people to break laws. Nevertheless, immoral officials thrive as the violators of laws grease their palms. So act remain an act in book never comes true. Encouragement of conversion of vehicles which are more than eight years old are not a good practice today [19]. Therefore, it is a great challenge so cope with the situation for the law enforcer.

Causalities relating NGV accident can lower by taking some preventive steps as shown in Figure 5. The recommended steps may be the followings (i) Fencing the CNG cylinder. (ii) The maximum service life shall be 20 years. (iii) All components of the system shall be fastened in a proper way. (iv) The container shall be installed such that there is no metal-to-metal contact. (v) Developing system of retesting certificate. (vi) Use of gas cylinders in well-ventilated areas, not in confined areas. (vii) Disconnect empty cylinders from equipment to avoid backflow issues. The visual inspection should be performed by a competent agency approved or recognized by the regulatory authority, in accordance with the manufacturer's specifications. Cylinders without labels or stamps containing mandatory information or with labels or stamps containing mandatory information that is illegible in any way must be removed from service. If the cylinder can be positively identified by manufacturer and serial number. A replacement label or stamping may be applied, allowing the cylinder to remain in service. Cylinders involved in collisions should be re-inspected by an authorized inspection agency. Building new CNG industry is no exception. The Ministry of Power, Energy and Mineral Resources should look into the matters of safety and security related issues involving CNG cylinders, conversion workshops and filling stations and help to reduce the number of accident. Be insured about the other accessories by traffic department.



Fig. 5- (a) Regulator outlet connection (1) and Cylinder value (2) [20], (b) Typical holding system

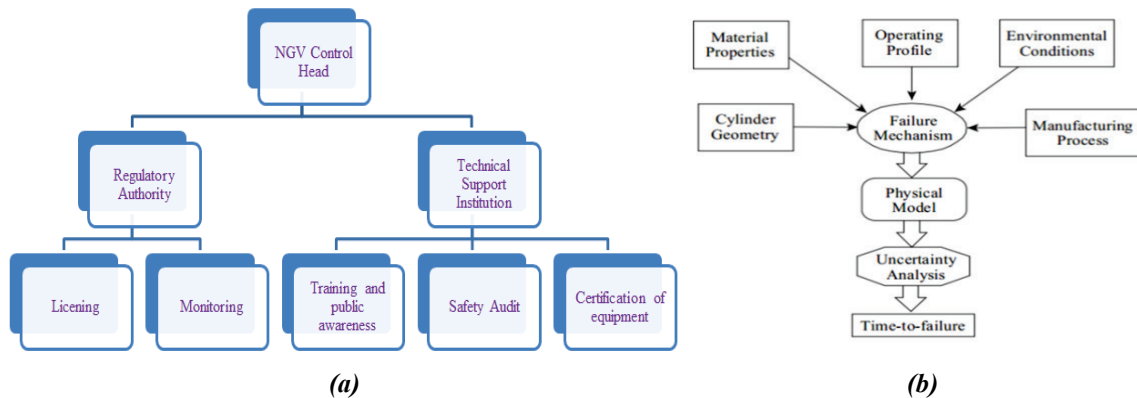


Fig. 6- (a) Typical regulatory framework, (b) Failure study process to prevent accident

Table 4- For cylinder safety a summary of the do’s/don’ts when working with gas cylinder

DO	DON'T
Ensure a regulator is fitted before use	Repaint a cylinder
Ensure cylinder is firmly secured	Change the markings on a cylinder
Ensure cylinders are stored away from ignition sources	Tamper with the gas cylinder test tag
Store full and empty cylinders separately	Remove the barcode from a gas cylinder
Ensure valve guards or caps are fitted	Roll cylinders along the ground
Use mechanical assistance when handling cylinders	Attempt to fight a fire involving a gas cylinder
Ensure adequate ventilation is available	Transport gas cylinders in the passenger compartment
Ensure exposure limits are not exceeded	Use a cylinder that shows evidence of damage

5 Regulatory Framework

Department of Explosives, Ministry of Energy and Mineral Resources, Bangladesh Road Transport Authority, Bangladesh Energy Regulatory Commission are law enforcer and statutory bodies [21]. The scopes of these bodies are statutes setting up the respective safety regulators. The decisions of the regulators may be challenged by judicial review under rules of the Gas, Cylinder and Articles. Transmission, distribution, NGV conversion, running in the road activities should requires permission from different government departments or organizations, including The Ministry of Energy and Mineral Resources, The Ministry of Law, The Department of Environment, and BRTA. The suggested framework should be like that shown in Figure 6(a). A recognized failure study process mandatorily developed as shown in Figure 6(a). The task of the framework will be insured the safe running of NGV by regular monitoring, growing awareness, arrangement training program and penalizing for the violator.

6 Conclusions

The above study finds the present prospects of NGV interconnected with safety standard and interference on implementation. The existing situation is going to be crucial, if proper steps not taken in first hand. The NGV related accident becomes common. The regulatory framework appears ineffective. Therefore, revision of CNG act and restraint the law in all levels associated with NGV are the prime challenges. Only 20% of convertible vehicles are running by CNG and many are on conversion line. However, this is huge enough to eat up the facility available. Thus new infrastructure is essential to service this most economic and environmental friendly transportation system. For any policy making, the socio economic condition besides environmental impact must consider. The findings from this study can be used in any safety assessment to construction a monitory framework within Bangladesh. It may be generalized after consideration of certain limitations. The study-population was selected purposively as the data is not available in the respective departments. Actually, there was no specific sampling frame in order to find out the required data to conduct the research. This study considers only the active passengers carrying NGVs. Further research can be undertaken taking into consideration in other major metropolitan cities of Bangladesh.

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