

Safe and Efficient Distribution Management of Liquefied Petroleum Gas for Domestic Usage

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Md. Delowar Hossain

Lecturer, Department of Chemical Engineering and Polymer Science,
Shahjalal University of Science and Technology, Sylhet-3114, Bangladesh.
E-mail: delowar46@gmail.com

Abstract

Domestic gas supply to consumers is a big concern of the government of Bangladesh as the reservation of natural gas will be exhausted within an era. To mitigate the domestic gas crisis, the government of Bangladesh has already introduced liquefied petroleum gas (LPG) as a suitable alternative energy source of natural gas for household consumers. Therefore, installation of proper gas distribution system throughout the country is essential to ensure the optimum LPG consumption maintaining adequate safety. As per depicted domestic gas distribution layouts in this study, gas distribution network installation from the regional petroleum gas stations to consumer's premises, in lieu of thousands of separate domestic consumption layout, is the most suitable one. For instance, imported LPG storage stations or crude petroleum refining industries will act as regional petroleum gas stations from where (liquefied) petroleum gas will be distributed to consumer's premise through piping network. In addition to regional domestic gas piping layout, several modifications in gas pipeline, gas stove and safety mountings at the domestic gas consumer's end are recommended to ensure the safe and efficient gas consumption.

Keywords: LPG Distribution System; LPG Management; Domestic Gas; Gas Stove; Safety Mountings.

1. Introduction

Bangladesh is a land of natural resources among which natural gas (NG) is dominant one. Major NG consumption sectors in Bangladesh are chemical industries (present gas demand only in fertilizer industries 316 mmcf/d), gas fired power generation plant (current output capacity 7437 MW and under-processing 6105 MW), transportation (current CNG demand 139 mmcf/d), domestic gas stoves and miscellaneous industries [1]. Actually NG is used directly or indirectly in every sector as direct or indirect heat source (gas stove, gas turbine for electricity production, boiler for steam production, heat exchanger etc.), raw material (to produce urea, H₂O₂ etc.), driving energy (gas engine vehicle) and so on. Current gas demand only for domestic sector is approximately 425 mmcf/d within the total gas demand 4250 mmcf/d; according to gas demand forecast, domestic gas demand will become 1196 within the total gas demand 10208 mmcf/d by 2041 [1]. In contrary, the NG reservoirs of the country are going to run out for continuously meeting the vast volume of NG demand. As per annual report of Petrobangla, 11.47 TCF reserved NG in Bangladesh will be exhausted within next 11 years at present 2960 mmcf/d production rate [2]. Considering the scenario, the government of Bangladesh promulgated a legal framework to stop new pipeline gas connection for domestic consumption and

also narrowed the approval of new industrial NG consumers. Surprisingly, approved domestic gas consumers are still consuming low priced pipeline NG instead of switching into alternative heat source. To make up the gap between NG supply and domestic gas demand, the government of Bangladesh introduced liquefied petroleum gas (LPG) in 1989, which is well known to everyone as LPG cylinder or LP gas or cylinder gas. The government also installed LNG (liquefied natural gas) terminal in Moheshkhali island in the Bay of Bengal in 2018 to make up the NG crisis in national gas grid. Indeed, from the inception of LPG, people still prefer to use NG instead of LPG for the household activity considering the risk factor and price issue [3,4]. Even though the domestic gas consumers are bound to switch into high priced LPG or LNG or other alternative fuel sources considering the huge gap between gas supply and demand (2754 - 3736 = -982 mmcf/d) along with narrowing NG reservation [1,2].

Consequently, numerous accidents are also happening due to improper household LPG distribution layout, insufficient safety mountings at end usage, inefficiency, unconsciousness, delayed maintenance and weak monitoring system etc. As per the department of explosive, Bangladesh, more than 900 accidents occurred for gas cylinder explosion which caused to injure around 1500 people from 2010 to 2019. Only in 2018 - 2019 fiscal year, 12 people died and 23

people burnt due to LPG cylinder explosion [5]. According to the annual report 2018 - 2019 of Titas Gas Transmission and Distribution Company Limited (TGTDC), 204 fire accidents happened only from gas stoves and 5887 accidents occurred due to gas leakage [6]. Following the news published in the country in 2019, 500 people died and thousands of people burned in last ten years due to gas explosion. Aforesaid statistical data are knocking to minimize domestic gas line fire by taking short-term and long-term initiatives immediately before being frequently watching mishap like Nimtoli tragedy; unfortunately, suitable initiatives are still loading.

Undoubtedly, LPG or LNG or LPG based SNG (synthetic natural gas) are the suitable alternatives to NG to mitigate the domestic energy crisis of the Bangladesh [7,8]. Between 2013 to 2018, LPG demand in Bangladesh has increased from 50,000 MT to 800,000 MT; so, the domestic gas demand is rising continuously [9]. Worldwide LPG consumption was over 284 mn t/yr within the total 292 mn t/yr LPG production only in 2015 [10]. Domestic sector consumes almost half of the global LPG consumption. 38% of global LPG production is contributed by crude petroleum oil refineries and remaining amount are produced from NG condensate fractionation [11]. Following the global LPG statistics and present gas reservation of the country, LPG dependency can be increased in Bangladesh as a suitable alternative source of NG to meet the domestic gas demand. Tariff of NG and LPG has to be imposed in such a way that domestic gas consumers become encourage to use LPG. Beside appeasing consumers by smooth gas supply, optimum gas consumption with zero domestic gas fire incident has to be ensured by modifying domestic gas distribution layout compatible for LPG usage and mounting mandatory safety instruments in domestic gas distribution system. In this study, several domestic gas distribution layouts for LPG are depicted; moreover, some additional safety features are recommended to install at consumer's end for consuming LPG safely in household activity.

2. Domestic LPG Distribution Layout

Supply, demand and reservation statistics of NG in Bangladesh indicate that dependency on alternative energy sources like LPG, LPG based SNG and LNG will be increased to fulfill current domestic gas demand [1,2]. But LPG is the most available substitute of NG as domestic gas stove fuel source in Bangladesh. For efficient and safe consumption of LPG, several proposals of LPG distribution system for domestic usage are depicted below.

2.1 Single Consumer of LPG

In Bangladesh, majority of the LPG consumers keep the LPG storage cylinder near the gas stove inside the

kitchen overlooking the instructions or standard LPG cylinder storage guidelines. Piping layout of individual LPG consumer are shown in Figure 1; where it is clearly depicted that single consumer usually keeps LPG cylinder around the gas stove (Figure 1a) or at the bottom free space of gas stove (Figure 1b) inside the kitchen.

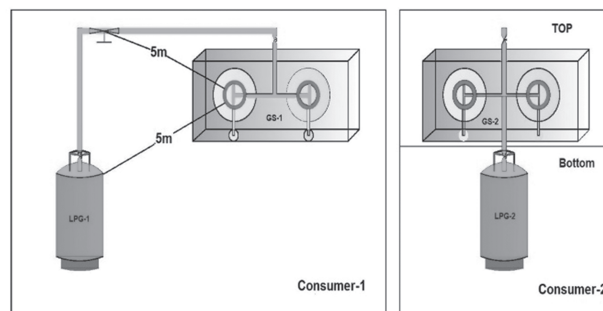


Figure 1: Single consumer of LPG; a) side storage of LPG cylinder (left), b) gas stove bottom storage of LPG cylinder (right).

According to Bangladesh LPG Act 2004 (Amendment 2016), generally above ground storage of LPG cylinder (below 2000 L) has to be kept 5 m away from the gas stove burner, building, community place and 1 m away from other LPG storage cylinders. LPG cylinder must not be stored in very warm place where adequate ventilation along with fire extinguisher are not available [12]. Following the above guidelines, piping layout shown in Figure-1b is totally risky which must be avoided. Piping layout in Figure-1a will be suitable one if consumers store LPG cylinder following the instructions; but in reality, most of the consumers stay indifferent to obey such guidelines. So, there is still possibility to initiate fire due to consumer's carelessness about guidelines and inadequate kitchen space. Where uniquely designed LPG appliances are required for such piping layout, violations of international standards, leakage risk, fire accident and improper inventory management are major drawbacks reported [13,14]. Considering the risk factor and aforesaid statistics of gas stove accidents, more suitable piping layout is required to find out for safe LPG consumption.

2.2 Multiple Consumers of LPG in Single Building

Clustered LPG cylinder storage and distribution system (Figure 2) for the consumers of a building can be a suitable option to the house owners as the government of Bangladesh is not permitting any new gas line connection and there is no possibility to add new consumers in near future. Two gas distribution layouts of clustered LPG cylinder storage are shown in Figure 2a and Figure 2b; where clustered LPG cylinder storage for multiple gas consumers of a building is depicted at the underground or ground floor of the building (Figure 2a)

and at the isolated shed or outside of gas consumer's building (Figure-2b) [15].

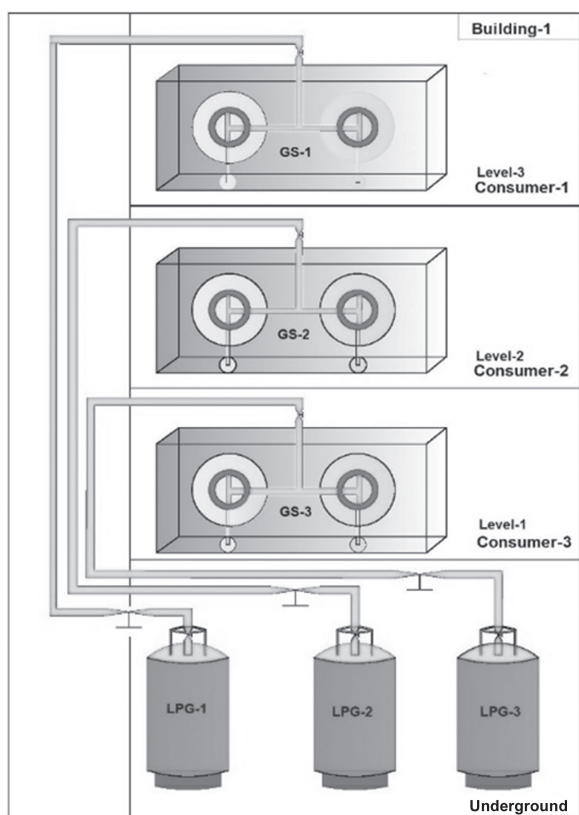


Figure 2a: Clustered LPG distribution layout for multiple consumers in a single building (Underground or Ground Storage)

Underground or ground LPG stored piping layout of a building is seemed safer layout for using LPG and hassle free to exchange cylinder compared to several single LPG consumer's layouts. For instance, the LPG cylinders must be stored in an isolated area of the ground floor with adequate ventilation and safety mountings [15]. In absence of such condition, if fire initiates at any LPG storage cylinder or LPG distribution line, there is a possibility to spread the effect to the entire stored LPG cylinders or distribution system [4]. Proper design and installation of the gas layout can slightly be sacrificed during the initial phase due to the lack of sufficient space; therefore, the possibility of occurring minor accident or major blast within the clustered LPG storage system will be increased [16]. If gas cylinder fire arises for any reason at the ground or underground or entrance of a building, people staying inside the building would not be able to exit as the residential buildings contain no emergency exit. Therefore, underground or ground LPG stored gas layout will not be a good choice for multiple consumers.

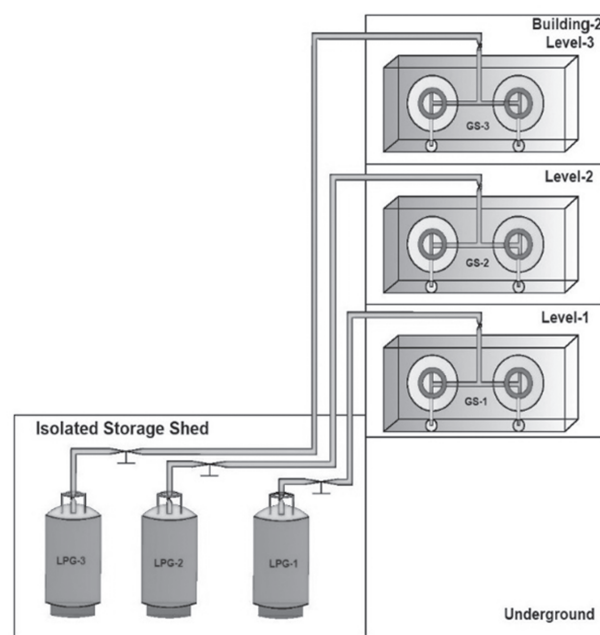


Figure 2b: Clustered LPG distribution layout for multiple consumers (Isolated Storage) in a single building.

Isolated shed or outside clustered LPG stored piping layout of a building is a good choice, if the isolated or outside LPG storage is fabricated following the latest guidelines of the department of explosive of Bangladesh or NFPA 58 or any other international standards. To follow such kind of gas piping layout, usually building owners allot very small space or the narrow space between two buildings to store clustered LPG in where firefighting and easy cylinder exchange are difficult. Therefore, isolated LPG stored piping layout is difficult to install considering space limitation in densely populated areas like Bangladesh.

2.3 Community-Based LPG Distribution

LPG supply station for community based consumers is comparatively better LPG storage and distribution layout (Figure 3) considering safety concern. In previous layouts, every consumer is to keep LPG cylinder inside or outside the kitchen i.e. every consumer is to keep a small explosion bomb which can blast if anyone fails to maintain individual distribution system properly. In this LPG distribution system (Figure 3), LPG will be initially transferred and reserved into the bulk LPG storage vessels (located at the residential area) from the number of LPG stored iso-tankers or directly from the refineries or imported LPG storage stations through LPG distribution pipeline. Finally, LPG will be distributed through piping network from the bulk LPG storage to thousands of consumer's gas stoves located at the different community areas.

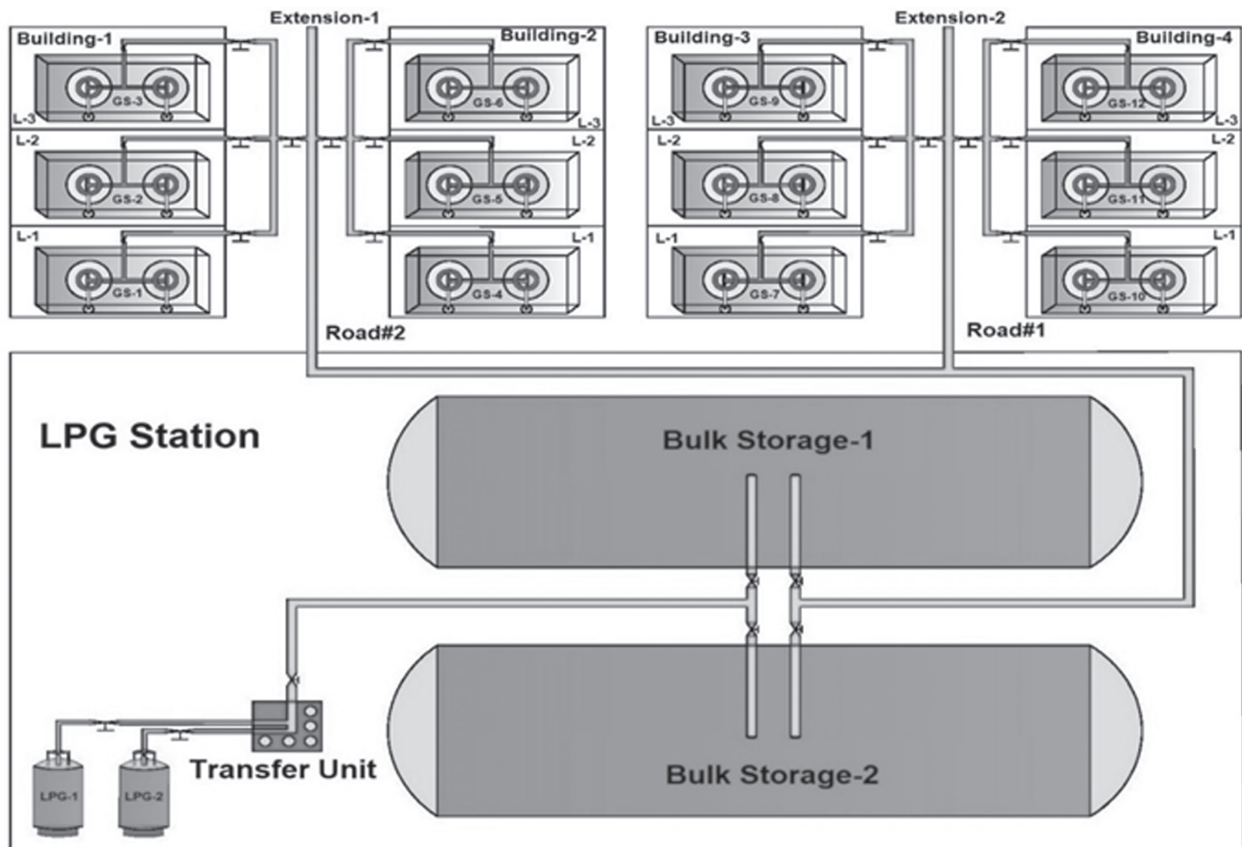


Figure 3: Community-based LPG distribution station [17]

Community-based LPG gas storage and distribution station has to be designed in such a way that can automatically transfer gas from incoming LPG cylinders to bulk LPG storage vessels by stage wise reducing gas pressure from 80 - 100 psig to 16 - 18 psig, then 5 psig and finally 0.5 psig. 0.5 psig pressurized bulk stored gas has to be supplied to different gas stoves of residential areas; if gas pressure goes below 0.5 psig, then gas supply pressure has to be increased or cut off automatically [12]. Operating single LPG storage station for certain community areas by technically skilled personnel with full-fledged safety is better than the thousands of cylinders handling by individual general consumers. But the main limitation of such layout is temperature rising of bulk stored LPG and dedicated space around community areas for LPG station installation [18]. Natural force damage, third-party excavation damage, flexible joint leakage, incorrect operation and corrosion damage can initiate fire accident in this distribution arrangement [17,18].

2.4 Consumers of LPG in Regional Areas

On the basis of aforementioned LPG distribution layouts, regional LPG distribution system throughout the country can be developed. According to this proposal, imported LPG storage stations or refinery industries will act as

regional (L)PG stations to directly supply (L)PG to the domestic consumers through regional piping network like current NG distribution system. Every regional (L)PG station will cover certain area on the basis of its capacity and regional energy demand. (L)PG stations will provide gaseous petroleum gas directly to end-users through piping network by maintaining operational parameters. For instance, regasification unit will convert the liquefied petroleum gas into gaseous form which will add additional safety layer along with energy optimization. Additional compressor unit can be installed in (L)PG stations to meet higher pressure requirement in any regional area. To analyze the advantages and limitations of regional LPG distribution system, Bangladesh is divided into seven sectors on the basis of geographical structure, raw material entrance facility through waterway, regional infrastructure, regional energy demand, existing energy stations, population density and transportation facilities which is shown in Figure 4. Probable location and number of PG stations are shown in Figure 4 to visualize regional domestic gas supply network on the basis of raw material entrance facility through waterway. But the actual number, site, and capacity of PG stations will be different; for which, specific feasibility study against every PG station installation will be required. In Figure 4, Probable (L)PG

station means petroleum gas station which are practicable, LNG covered (L)PG station means LNG can meet the regional domestic gas demand where regional LPG stations are insignificant, and Infeasible (L)PG station means petroleum gas station which may not be feasible.

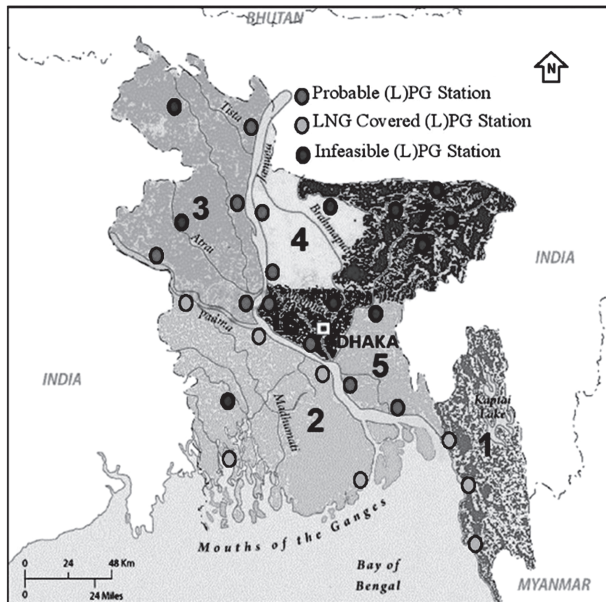


Figure 4: Probable LPG stations for proposed regional domestic gas distribution system in Bangladesh.

Sector-1 has already an LNG terminal which is providing gas through pipeline to the domestic and industrial gas consumers of the region. Several refinery industries are also operating in this region; numerous refining industries and LPG storage stations are under construction to fulfill the energy crisis not only of the region but also the whole country. In Sector 2, existing several refineries and LPG cylinder filling stations are also serving other sectors after meeting the regional household gas demand. Additional crude petroleum refining industries, imported LPG storage stations and more LNG terminals can be installed to fulfill the industrial and household gas demand of these regions as well as the country if require. As per the proposal, direct piping network can be installed between the PG stations

and regional domestic gas lines to directly supply (L)PG among the end-users of the areas. But the installation of pipe network in the entire sector 1 and 2 might not be possible due to the geographical structure of land. So, the government of Bangladesh can plan to transfer additional gas from sector-1 and 2 to sector 5 and 6 to meet domestic and industrial gas demand.

In sector 3, 4 and 5, crude petroleum refining industries and LPG stations are practicable to install, but not LNG terminal. In addition to the existing LPG stations of these regions, additional LPG storage stations or refinery industries i.e. (L)PG stations can be installed to supply gas to the household and industrial gas consumers through direct gas distribution network.

The most challenging task is to fulfill the gas demand of household, industrial, vehicle and commercial consumers of sector-6 as it is densely populated region where most of domestic gas energy of the country is consumed [19]. Gaseous energy demand for household usage of this region can be met up by NG, LNG, LPG, LPG based SNG which have to import from other regions or sources. Currently, NG and LPG are supplying into this sector from other sectors through NG distribution piping network and LPG cylinders respectively. Installation of crude petroleum oil refinery or LPG station in this region will be required more feasibility survey due to the narrow raw material entrance facility over river and suitable site shortage. Following all the limitations, proper action plan is required to ensure smooth gas supply in future to the consumers of the area. Sector-7 is not a suitable area to install LNG terminal or refinery industries or LPG stations as the imported raw material arriving into this region through waterway is quite difficult. Currently, a number of NG wells is operating in this sector from where NG is being supplied all over the country [7]. As the reserved NG of this region will be exhausted within a decade, how the consumers of this region will survive in future is a big concern. Relying only on imported energy will neither be cost-effective nor be feasible as energy transportation into the region will require long piping network or high road transportation cost. So, NG supply from this region to other parts of the country should be restricted considering the future energy demand of this region.

Table 1: Comparative analysis of regional LPG distribution system

Parameter	Sector - 1	Sector - 2	Sector - 3	Sector - 4	Sector - 5	Sector - 6	Sector - 7
Existing domestic gas	NG, LPG, LNG	NG, LPG	NG, LPG	NG, LPG	NG, LPG	NG, LPG	NG, LPG
Domestic energy demand [19]	Steadily increasing	Lowest; Steady	Steady	Steadily increasing	Steadily increasing	Maximum; Rapidly rising	Slowly increasing

Existing NG well	Very few	Very few	Absent	Absent	Multiple	Very few	Numerous
LNG facility	Yes	Practicable	Not practicable	Not practicable	Not practicable	Not practicable	Not practicable
(L)PG stations	Numerous; New LNG, LPG stations can be installed	Numerous; New LNG, LPG stations can be installed	Present few; New LPG stations can be installed	Present few; New LPG stations can be installed	Present few; New LPG stations can be installed	Multiple Space crisis shackles to install new station	Present very few; RW transfer is costly
RM entrance facility	Waterway	Waterway	Waterway	Waterway	Waterway	Waterway	Roadway
Imported RM transfer from mother vessel to LPG station	Small oil tanker ship or pipe - in large scale	Small oil tanker ship or pipe - in large scale	Small oil tanker ship	Small oil tanker ship	Small oil tanker ship	Small oil tanker ship	Small oil tanker plus road transport
Piping network installation	Difficult for land structure	Practicable	Long pipe network require	Practicable	Practicable	Practicable	Long pipe network require
Suitable space management	Possible	Possible	Possible	Possible	Possible	Difficult	Difficult

Table 2: Comparative analysis of domestic LPG distribution systems [4,12,13,14,16,17,18]

Property	Single Consumer	Multiple Consumers	Community-Based Consumers	Regional Consumers	Ref.
Distribution network	Station => Hub => Agent => End - user*	Station => Hub => Agent => End-user	Filling Station => Distribution Station => End-user	Station => End - user	*14
Inventory management	Stock at each distribution center	Stock at each distribution center	Two step stock	Centralized Stock	
LPG storage	Above ground	Above ground	Underground or, Above ground	Underground or, Above ground	
LPG temperature rising control	No control	No control	Design dependent	Capable to control	

Pressure relief device	Absent	Design dependent	Present*	Present	*17, 18
Pressure Regulator	Present	Present	Multi-stage regulation	Multi-stage regulation	
Leak on flexible connection	More	More	Less	No flexible joint	
Gas detector failure	Not applicable	Not applicable	Occur	May occur	
Pipe connection failure	More	More	Less*	Less	*17
Fire accident	High*** (Small effect)	High** (Large effect)	Low* (Massive effect)	Low (Massive effect)	***5, **16 *17
Firefighting facility	Absent	Depend on consumers	Well-equipped	Well-equipped	
Space Management	Adjustable	Difficult to provide dedicated space	Space crisis	Manageable	

3. Modifications at Consumer's End

Current gas (NG or LPG) consumers of Bangladesh are following certain framework to consume gas in their premises. Some modifications at end-user's framework are recommended for efficient and safe usage of LPG and NG which are depicted below:

3.1 Gas Flowmeter Installation

In Bangladesh, domestic gas bills of NG consumers are prepared on the basis of the number of gas burners (currently, 925 BDT for single burner and 975 BDT for double burners) and the volume of gas consumption (12.6 BDT/m³) [6]. Due to conventional weak gas bill processing system, domestic gas consumers are consciously consuming more gas than the requirement. Domestic gas consumers of capital city are burning NG worth of 332 crore BDT per year which is equivalent to 643410852 m³ gas per year to purify drinking water [6,20]. Same amount of LPG will also be burnt if LP gas is used. To preserve the gas from wasting, gas flowmeter installation at individual domestic gas consumption pipeline is recommended whether the pipeline gas is NG, LPG (not for the single consumer layout), LNG or SNG. Gas flowmeter will measure the actual gas consumption by individual user which will subsequently help to prepare consumer's gas bills. For instance, TGTDCCL has installed prepaid gas flowmeter with few domestic gas

lines in Dhaka city; but need to install with every gas consumption line [6]. Mounting flowmeter would require large investment and operating cost; even though gas flowmeter is recommended to install with each consumer's line considering energy reservation scenario of Bangladesh.

3.2 Gas Stove Basement

Gas stove baseplate is recommended to install permanently with the basement. But the gas stoves, which are currently available in local market of Bangladesh, do not have option to fix up the baseplate with the basement. Hence, there is possibility to initiate fire or accident by disjoining gas inlet hose pipe joint from gas supply line due to impact force acted upon gas stove while subconsciously putting or removing cookers from gas burners. To stop gas stove slipping for impact force or long time use, gas stove manufacturers should include baseplate mounting feature.

3.3 Inlet Gas Valve Position

At present, pipeline NG flow is connected to gas stove by switching valve which is located immediately before the gas stove (usually, within 6 inch) inside the kitchen. If any fire accident initiates around gas stove during operation, then the fire will not be extinguished at initial stage by switching off the inlet gas valve due to its improper location. As per proposal to install LPG piping

distribution system like current NG distribution piping network, inlet gas supply valve location has to be shifted. So, inlet valve of NG or LPG supply line is recommended to install at the entrance of the kitchen and at least 5 m away from the gas stove burner (shown in Figure-1).

3.4 Hose Pipe Joint

Generally, gas stove is connected with gas supply line via plastic hose pipe and steel clamp. After certain time period, cross-sectional area of hose pipe changes due to the slight change of gas stove position or the MOC (material of construction) of hose pipe and subsequently gas flow rate reduces. In such case, it is difficult to identify the actual reason behind being reduced gas flowrate. So, instead of temporary plastic hose joint between gas supply line and gas stove, permanent joint by steel pipe and fittings should be installed with suitable MOC like gas line materials (ASTM A106, EN1057, API5L Grade-B, ASTM D2513 or ISO 4437) [12].

3.5 Burner Design of Gas Stove

Various designs of burner head are available to increase thermal efficiency which can be installed with gas stove such as radial flow ring burner, swirling central flow burner, star burner, regular burner, flat face burner, flower face burner, heat recirculated burner etc. Usually, thermal efficiency using conventional gas burner can be achieved between 30 - 69% [21,22,23]. But, suitable burner head design, flat bottom cooking vessel and optimum gas flow can increase the thermal efficiency of conventional gas stoves [24]. Thermal efficiency of conventional gas burner is different for using pipeline NG and LPG [25]. Maximum 73% efficiency can be achieved with the usage of porous media [22]. So, there is opportunity to conduct research to improve domestic gas burner efficiency. To extract maximum heat from LPG burning, consumers have to select right gas burner. For efficient gas consumption, energy regulatory body should influence the manufacturers and gas consumers to manufacture and use the most efficient burner respectively.

3.6 Temperature Detection System at Gas Stove

Gas stove should contain heat or temperature detection sensor as heat or temperature is the main basis to operate and evaluate the performance of gas stove. But people are consuming gas without knowing the actual heating value or temperature. For instance, mounting a mechanical temperature sensor or any other cheap temperature sensor with the gas burner to indicate burner temperature would be advantageous for consumers to optimize the gas consumption and to select the most efficient gas stove with user friendly operation.

3.7 Gas Detection System

Smelling substance is mixed with domestic gas (NG, LPG or LNG) before supplying into pipeline which helps to detect gas leakage. So, smell of gas must be checked before light up the gas burner. Even though consumers can keep open the gas stove switch subconsciously when pipeline contains no gas supply; which further will allow to spread gas throughout the gas consumption area and subsequently can initiate fire. Therefore, adequate ventilation inside the kitchen must be ensured following the guidelines of world health organization which must be approved from fire and safety authority [26]. In advance level of safety, gas detection along with alarm system installation inside the kitchen is recommended to prevent such accident to be happened [27,28].

3.8 Gas Fire Extinguisher

Gas consumers are recommended to keep gas fire extinguisher, such as dry chemical powder extinguisher, at the entrance of kitchen room or in any other suitable location to fight with the accidental fire initiated inside the kitchen. Fire can easily be extinguished at initial level using gaseous fire extinguisher before turning into massive one.

3.9 Maintenance

Domestic gas line fittings and gas stove joints need to be repaired or replaced after certain time interval; but in reality, consumers stay indifferent to change or repair fittings until the interruption or collapse of domestic gas consumption system. To minimize accident due to gas leakage in domestic gas lines, preventive maintenance should be done along with the regular maintenance following the maintenance guideline like BS 6172.

3.10 Training

For the safe pipeline or cylinder gas usage, foundation training program is recommended to organize in regular basis by the fire service and civil defense department or gas distribution companies or any other validated organization for the end-users of household gas from where consumers will acquire knowledge about the safe operation of gas stove, optimizing the gas consumption, small or large firefighting, cylinder explosion, primary treatment and so on [26,29]. Without completing the foundation training program, consumers should not be licensed to operate gas based burners in any house.

3.11 Monitoring and Approval

To minimize domestic gas fires, following measures are recommended to maintain by the gas distribution authority:

- a) Ensure requirements of validation for individual gas distribution system before giving approval to pipeline or cylinder gas consumers.
- b) Strictly instruct the end-users for checking the gas line

fittings regularly and taking necessary steps.

c) Form dedicated vigilance team to routinely monitor the overall gas distribution system.

d) Take immediate legal action based on the report of vigilance team against any mismanagement.

e) Analyze the domestic gas consumption points and subsequently, create pressure on the corresponding authority to rectify their system like WASA to supply purified water.

4. Conclusion

As the NG supply to new domestic gas consumers through pipeline is suspended, consumers have to switch into alternative form of energy sources like LPG, LNG, SNG etc. In Bangladesh, SNG is not available for domestic usage. But LNG is being supplied for the household consumption only in sector-1 with high selling price due to its high investment and operating cost. Among these sources, LPG is the most available substitute of NG as both the crude petroleum refineries and imported LPG stations add LPG to make up the domestic gas crisis at competitive price. So, LPG will be the prospective alternative energy source for domestic consumption in Bangladesh. Several proposals for proper LPG distribution have been depicted; which conclude that, installing PG stations throughout the country considering regional gas demand are most preferable. Hence, centrally controlled PG stations, from where (L)PG will be directly supplied to regional domestic consumers through distribution network, are more advantageous for LPG supply instead of thousands of individual domestic consumer's layouts. Besides the suitable LPG distribution layout, some modifications such as prepaid gas flowmeter installation, gas stove design upgradation and safety mountings addition are essential at domestic gas consumer's end for optimum gas consumption with safety.

Nomenclature

NG	Natural Gas
CNG	Compressed Natural Gas
SNG	Synthetic Natural Gas
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
PG	Petroleum Gas, (L)PG
RM	Raw Material
TCF	Trillion Cubic Feet
mmcf/d	Million Cubic Feet per Day
mn t/yr	Million metric Tons per Year

MT	Metric Ton
L	Liter / Level
m	Meter
m ³	Cubic Meter
MW	Mega Watt
W/mm ²	Watt per millimeter square
BDT	Bangladesh Taka
GS	Gas Stove
MOC	Material of Construction
ASTM	American Society for Testing and Materials
API	American Petroleum Institute
ISO	International Organization for Standardization
EN	European Norms
NFPA	National Fire Prevention Association
TIB	Transparency International Bangladesh
WASA	Water Supply and Sewerage Authority
TGTDCL	Titas Gas Transmission and Distribution Company Limited

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