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PROSPECTS OF LIQUEFIED GAS IN BANGLADESH ECONOMY AS A MOVE TOWARDS FUEL DIVERSIFICATION

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ABSTRACT

Traditional dependence on fossil fuel has led to the Economy of Bangladesh being confined to energy shortages, marginalizing the development prospects of this energy South Asian economy. The country has also relied heavily on its indigenous supply of natural gas particularly for electricity generation purposes. However, following the inappropriate subsidized pricing of natural gas in the country has led to over-exploitation of this resource and together with technical inefficiencies holding back new natural gas field discovery has pushed the nation towards running out of this energy resource by 2031. Thus, the aim of this paper is to discuss the prospects of liquefied gaseous use in Bangladesh, especially in the form of LNG and LPG, as a strategy to embrace fuel diversification within the Bangladesh economy in order to relieve the existing pressure on natural gas demand.

Contribution/ Originality: This study contributes in the existing literature by making a novel attempt in providing a qualitative analysis of the prospects of energy diversification in Bangladesh in the form of a renewable energy transition from use of traditional fossil fuels to liquefied natural and petroleum gases.

1. INTRODUCTION

Energy insufficiency is a predominant feature of all developing nations across the globe. It is universally believed that the incompetence of these nations to meet their own energy demand is one of the main factors limiting their development processes. Bangladesh over the years had faced the same fate as all other developing nations being unable to match local demand for energy. Thus, the nation's energy crisis over a prolonged period of time has generated negative externalities on the economy as a whole, depriving the nation of potential development. A key factor attributing to the nation's deficit between energy demanded and energy supplied could be due to the dependence on a limited number or energy resources, primarily natural gas (Mozumder and Marathe, 2007). Thus, heavy reliance on these few energy resources has often led to shortages in their supplies and had led their reserves on the verge of being exhausted. It has been empirically acknowledged that it is impossible for a nation to solely depend on a limited number of energy resources and generate an adequate amount of energy that is needed by the population. Hence, underscoring the necessity of ensuring energy for all, a nation should ideally diversify its energy resources and tap all options available at disposal. A possible means of diversifying energy-use could be in the form

of a non-renewable to renewable energy transition and thus moving away from the traditional dependence use of fossil fuels (Murshed, 2018).

Energy diversification is crucial when it comes to small reserves of traditional energy resource reserves. Moreover, energy diversification also complements the global drives to go green via switching from use of non-renewable energy resources to greater use of renewables. In the context of Bangladesh, diversification of energy resources has become mandatory as the nation's natural gas reserve is put to the sword and is expected to last till 2031 unless drastic steps are taken to reduce the dependence on natural gas employment. Bangladesh is heavily reliant on natural gas especially when it comes to electricity generation (Amin and Murshed, 2017). In addition, imported fuels also supplement electricity generation in the country. However, dependence on these energy resources has asserted in adversities within the economy in the form of shortages in natural gas supply and surge in fiscal burden arising from the oil import bills. Thus, energy resource diversification has become the utmost important agenda for the nation.

One way of guaranteeing energy security could be being self-sufficient in the production of energy resources. However, being self-sufficient in it is a humongous challenge which encourages the prospects of Cross-border Energy Trading (CBET) as a potential option to resolve the energy crisis in Bangladesh (Amin and Murshed, 2016). Engagement in CBET is pretty much in line with the energy diversification mechanisms. A possible mode of undertaking energy diversification policies via CBET could be through the introduction of liquefied gaseous energy resources in Bangladesh's energy sector, mainly in the form of imported Liquefied Natural Gas (LNG) and Liquefied Petroleum Gas (LPG). Both these energy resources can be exemplary in mitigating Bangladesh's energy poverty and simultaneously attribute towards the development of the economy. Adoption of LNG and LPG in the national energy framework of Bangladesh is expected to be beneficial to the economy in three particular ways. Firstly, it would help the nation to get over its mono-fuel dependency whereby it would no longer have to be reliant on the use of indigenous natural gas. As a result, natural gas usage in the economy can be lessened which would ensure its reserve to last beyond 2031. Therefore, it can be said that LNG and LPG usage can contribute to secure natural gas security in Bangladesh, keeping its supply for future generation uses. Secondly, LNG and LPG can relieve the nation from the fiscal burdens arising from crude oil imports. These two liquefied gaseous energy resources are relatively cheaper sources of energy compared to imported fossil fuels and as a result, importing LNG and LPG instead of crude oils can effectively cut down the nation's import bills. Finally, LNG and LPG, being relatively environment-friendly energy resources, can befittingly reduce the emission of harmful greenhouse gases keeping the environment clean. Lowering carbon emissions is extremely important for Bangladesh following the nation's vulnerability to natural calamities arising from environmental degradation. However, the ultimate goal of incorporating LNG and LPG in the national energy framework of Bangladesh is to partially diversify its energy resource usage which would ensure energy sufficiency and foster economic development of the nation.

The purpose of this study is to examine how alternative fuels in the form of LNG and LPG can supplement the existing energy resources in Bangladesh, ensuring sufficient and sustainable energy supply. It furthermore aims to contribute to the development of LNG and LPG markets in Bangladesh by highlighting the economies of using these energy resources and also shedding light on the possible barriers that can hold back the LNG and LPG market development processes. Overall, this paper aims to critically analyze the prospects and constraints of LPG and LNG in the Bangladesh economy. This sort of study is not only important for Bangladesh but it also provides some useful thoughts for other developing countries having similar economic structure. This study is planned for a twofold methodological approach. Firstly, a general overview with regard to the prospects and constraints of LPG and LNG uses is provided incorporating collection and processing of relevant secondary data available from the literature on the economies of using these two energy sources. Both quantitative and qualitative analyses have been carried out. Secondly, few case studies have been analyzed to understand the importance of LPG and LNG market development in the context of developing economies. To the best of our knowledge, no other study previously has

specifically addressed the prospects of liquefied gases in Bangladesh, suggesting their inclusion into the national energy policy and taking appropriate steps in the development of the associated markets.

The remainder of the paper is as follows. Section 2 provides a general outline of Bangladesh's energy sector followed by section 3 that highlights the LNG and LPG scenario in the country. Moving on, section 4 sheds light on the upcoming and future prospects of LNG and LPG market development in Bangladesh while the associated barriers upholding LNG and LPG market development are provided in section 5. In section 6, the worldwide usage of LNG and LPG are put forward for Bangladesh to draw a new leaf from the international best practices in LNG and LPG usage. Finally, the latter part of the paper contains the conclusions followed by the possible policy recommendations that can be considered by the government of Bangladesh.

2. GENERAL OVERVIEW OF ENERGY SECTOR IN BANGLADESH

Access to energy has become essential to the functioning of modern economies and the government of Bangladesh has been putting its best efforts to develop the indigenous energy resources, which ultimately plays a vital role in the socio-economic development of the country. Energy is considered to be one of the major factor fostering economic development drives in Bangladesh. However, the overall energy use in the economy is very low which is evident from a report by the IEO (2015) in which the total energy use in Bangladesh in 2012 was merely 0.20% of world energy consumption. Moreover, the per capita energy use in the country is also quite low when compared to other peer developing countries. According to the figures shown in Table 1, the per capita energy use in Bangladesh was around 212.52 kg of oil equivalent in 2013 which was lower than the neighboring South Asian nations like India, Nepal, Pakistan and Sri Lanka. Furthermore, it is even lower than the per capita energy consumption in the Sub-Saharan African countries, let alone that in the entire world. Such low energy consumption per capita figure is even more alarming for Bangladesh because the country is aiming to achieve the tag of a middle-income country by 2021 whereby it is far behind the average per capita energy consumption figure of 2008.5 kg of oil equivalent on average in middle-income countries.

Table-1. Per capita energy use in different countries

Country/Countries	Energy Use Per Capita (kg of oil equivalent) as in 2013
Bangladesh	215.52
India	606.05
Nepal	369.68
Pakistan	474.86
Sri Lanka	487.52
South Asia	672.64
Sub-Saharan Africa	488.06
Lower Middle Income	744.6
Middle Income	2008.5
World	3104.38

Source: World Bank (2016).

However, the annual growth rate of energy use in Bangladesh is relatively higher than that of the other South Asian countries. According to a statistical report by the WB (2016) the growth rate of energy in the country was about 5% between 2000 and 2010, which was greater by 1 percentage point than the energy growth rate in India. Table 2 presents the growth rates of energy use in selected South Asian countries between 1980 and 2010.

Table-2. Energy Growth Rate of Bangladesh and Neighbouring Countries

Country	Energy Growth Rate (1980-2010)	Energy Growth Rate (2000-2010)
Bangladesh	4.3%	4.8%
Sri Lanka	2.5%	1.6%
Pakistan	4.0%	2.6%
Myanmar	1.3%	0.8%
Nepal	2.6%	2.1%
India	4.0%	3.8%

Source: WB (2016)

Domestic natural gas and solid biomass account for the majority of Bangladesh's total primary energy consumption with the remainder being covered by imported oil, coal, and hydropower and solar energy. In 2015, Bangladesh's primary energy consumption was estimated to be generated 62% from natural gas, 12% from traditional biomass, 21% from imported oil, 2.5% from coal, and 2.5% from renewables. Fossil fuel comprising of coal, oil, petroleum, and natural gas products represent around 85% of total energy consumption in Bangladesh.

Although the country has shown some progress to achieve macroeconomic stability and had maintained an annual growth rate of 6.34% on average from 2011 onwards, it still continues to face significant challenges in the forms of underdeveloped infrastructure and energy deficits. In Bangladesh, electricity is the widely used form of energy input which is tapped to facilitate most of its economic activities. The government has envisioned ensuring 100% electrification rate by 2021, but currently, only 74% of the population has been blessed with access to affordable and reliable electricity supply. It is a matter of serious concern since rural electrification rate is still around 40% and has to be increased dramatically in order to attain the government's stated goal. The demand for electricity in Bangladesh is mainly stimulated by economic, technological and social advancements. The electricity generation capacity in the country has been doubled recently which can be endorsed to operations of the privately owned Quick Rental (QR) power plants over the last few years. Although the Bangladesh government has adopted a comprehensive electricity development strategy for exploring supply-side options along with demand management, still the country is unable to ensure the necessary electricity supply to meet its local demand.

One of the many reasons behind the gap between electricity demand and its supply in the economy is the fact that an addition in the installed capacity was not reflected in terms of proportional increase in electricity generation as some of the existing plants remained out of operation for maintenance, rehabilitation, and overhauling, while the capacities of some plants may also be derated due to aging. Moreover, almost 62.5 % of total electricity production in Bangladesh is fueled by natural gas. Such heavy reliance on natural gas is also an ominous sign for the nation since its natural gas reserve, at the current rate of exploration and consumption, is expected to be exhausted by 2031. Thus, shortage of natural gas is the major constraining factor for low installed capacity utilization in Bangladesh's electricity sector. Currently, the electricity sector of the country is dependent on natural gas supply and imported petroleum products like High Speed (HS) furnace oils. However, the use of these imported fuels in case of disruptions in natural gas supply exerts pressure on the nation's fiscal burden in the form of high import bills. Hence, these call for immediate fuel diversification with the underlying notion that effective energy policies should ideally ensure tapping all possible sources of energy, sufficient supply of energy for various uses and equitable access of energy to all segments of the society.

3. LNG AND LPG SCENARIO IN BANGLADESH

The use of LNG in Bangladesh is yet to make its way forward in spite of measures taken to introduce LNG in the national energy policy of the country. Following the acute shortage in supply of indigenous natural gas, the government in 2010 made up its mind to develop the infrastructure necessary to cater to LNG import. As a part of the development plan, the government decided to build a Floating Storage Regasification Unit (FSRU) with the anticipation of importing LNG by 2013. However, this project finally could not proceed following numerous constraints faced by the government. As a result, despite having immense potential in executing fuel diversification

in the country, LNG usage did not take off as per plans. A second attempt to introduce LNG in the national energy market came about in 2011 when the government signed a memorandum of understanding with Qatar Petroleum and expressed the desire to import 4 million tonnes of LNG per year. However, the deal is yet to be finalized and as a result LNG market development in Bangladesh once again was halted. Nevertheless, recently on March 2016, the government signed an agreement with the Excelerate Energy Company to build the FSRU terminal at the Moheshkhali Island. As per the agreement, the FSRU will have a storage capacity of around 1, 38,000 cubic meters with an overall capacity of handling 5 million metric tonnes per annum. Moreover, the FSRU will have a regasification capacity of 500 million standard cubic feet of gas per day. Upon successful construction of the FSRU, it is expected that Bangladesh can start importing LNG by early 2018. Apart from this floating gasification venture, the government has also sanctioned funds to set up two onshore LNG terminals at Payra in Patuakhali and Matarbari in Moheshkhali. Therefore, it can be anticipated that LNG will make its way forward in the Bangladesh energy sectors within a couple of years from now.

On the other hand, LPG has already made its way in Bangladesh on a nominal scale and is expected to take off in an enormous manner soon. Unlike LNG, LPG is produced locally as locally produced LPG accounts for 13% of the total supply while the rest 87% is generated from LPG imports. However, currently, there is a huge mismatch between the demand for LPG and its supply within the country. At present, the LPG demand-supply deficit lurks around 3, 50,000 tonnes. A possible reason behind this could be due to the exponential growth in LPG demand over the years which were not correspondingly matched by the relatively lower growth rate of LPG consumption. The domestic household sector holds the lion's share of total LPG employment within Bangladesh. It is noteworthy of mentioning that the LPG industry is dominated by private sector involvement. LPG is imported only by private companies that are also in charge of storing, bottling, distributing and marketing of LPG in Bangladesh. Some of the leading private companies include Bashundhara LP Gas Limited, Jamuna Spacetech Joint Venture Limited, Omera Petroleum Limited, etc. Conversely, public companies are entitled to produce and supply LPG locally. The state-owned LPG supplying entities include Bangladesh Petroleum Corporation (BPC) and Rupanatarita Prakritik Gas Company Limited (RPGCL). Moreover, more private companies are in the pipeline to enter the market and import LPG in Bangladesh due to LPG being an energy resource of choice.

4. PROSPECTS OF LNG AND LPG USAGE IN BANGLADESH

4.1. LNG proposition in Bangladesh Energy Sector

Following the enormous reserve of natural gas, Bangladesh once had the possibility of exporting its indigenous natural gas. However, due to inappropriate pricing strategies such prospects soon disappeared and currently, the nation faces an acute shortage of natural gas supply, hampering its economic development processes. In order to counter the natural gas crisis, the Bangladesh government can look up to importing LNG as an alternative source of energy. The prospects of LNG in Bangladesh are promising which make it an energy resource of choice. The potential use of LNG in the country could be in the transport sector which would generate multidimensional positive externalities in the economy. In addition, switching to LNG based electricity generation in the future can also curb Bangladesh's electricity deficits to a great extent. Out of the several benefits associated with LNG usage, the relatively low cost of per unit LNG compared to that of conventional imported liquid petroleum products makes LNG a plausible option to initiate partial fuel mix within the energy sector of the country. However, the option of LNG overall is ranked medium in terms of affordability since the price of LNG is a touch on the higher side as compared to the prevailing local gas price.

Another promising feature of LNG is that it expands almost 600 times to reach its gaseous state which implies that LNG is a highly portable energy source. Upon regasification, one unit of LNG can produce 600 units of natural gas which means that a large amount of natural gas can be easily stored and transported at low pressure. Thus, it can be a breakthrough if employed in the transport sector in Bangladesh. At present, the transport sector is heavily

dependent on locally produced Compressed Natural Gas (CNG) and imported petroleum products. However, the acute gas shortages and fiscal burdens arising from crude oil imports have had a negative impact on the macroeconomic indicators of the nation. Thus, the introduction of LNG into the transport sector can not only cut down on the natural gas demand but would also relieve some of the associated burdens arising from huge import bills.

LNG is considered to be an environmentally friendly source of energy compared to the other fossil fuels that are associated with harmful emissions leading to environmental adversities all around the globe. It has been empirically acknowledged that LNG usage can effectively mitigate nitrogen dioxide emissions into the atmosphere. Thus, the employment of LNG in the transportation sector can reduce the prevailing volume of air pollution in Bangladesh. Air pollution in the country has become a serious concern for the government which is determined to leave no stones unturned in controlling harmful emissions resulting from the exhausts of vehicles. Although the per capita carbon emission in Bangladesh is very low compared to the global average carbon emission, the introduction of LNG into the transportation sector can significantly reduce the emissions further and also ensure improved health standard of the people.

LNG ranks high in terms of reliability since interruptions in the sustainable supply of LNG are unlikely to be encountered. This is because the current global market for LNG is oversupplied providing extra leverage for the buyers. Furthermore, the global LNG exporting capacity is expected to be doubled in the next few years as well. As a result, this global glut of LNG exporting capacity is gradually creating a buyers' market worldwide whereby LNG is becoming the most reliable source of energy supply for importers. Reliability in energy supply is key to achieving economic development, especially for developing countries like Bangladesh that are extremely vulnerable to energy price shocks and disrupted supplies. The adequate global LNG reserve provides insurance to LNG importers against short-term and medium-term supply disruptions and provides incentives for long-term trade agreements. In addition, the geographic location of Bangladesh also makes it favorable in diversifying its LNG importing partners. For instance, Bangladesh's proximity with India, Australia and Singapore enables it to be not solely dependent on Qatar for importing LNG.

4.2. LPG Proposition in Bangladesh Energy Sector

LPG demand in Bangladesh is expected to rise in a drastic manner in a couple of years from now. Employment of LPG in Bangladesh is usually made for cooking purposes both in the rural and urban areas. Thus, the effects of using LPG vary across geographic locations across the country. For instance, in the rural areas traditional biomass-based cooking fuels are used predominantly. However, combustion of these fuels emits harmful gases that not only affect the health of women who are engaged in cooking and heating activities but also releases greenhouse gases into the atmosphere. Hence, use of biomass to fire stoves in the rural areas exerts negative externalities at both household and social scales, which in turn may hamper the socioeconomic development in Bangladesh. This is where LPG emerges as a solution to these rural problems particularly due to the fact that LPG accounts for low combustion emissions and does not produce black smoke either. Moreover, switching to LPG from traditional biomass-based fuels also raises the efficiency level which to some extent is important for energy conservation. The economies associated with LPG usage are just not confined to the rural areas but it also affects the urban areas where natural gas is the source of cooking fuel. Thus, the introduction of LPG in large scale would relieve the pressures of the natural gas demand. Following the natural gas shortage in Bangladesh, the government in 2009 stopped supplying new gas connections in residential areas with the vision of enhancing LPG uses. In addition, the government also decided to all duty and taxes on LPG imports in order to promote greater use of LPG as an alternative to natural gas usage. It is to be mentioned that the government was particularly interested in encouraging widespread use of LPG within the economy because LPG market development, unlike that of LNG, can be fostered using the existing energy infrastructure of the nation.

Another possible use of LPG would be in the transport sector in Bangladesh whereby it would supplement LNG in replacing the traditional CNG and liquid petroleum fuels. By the end of 2025, the government has envisioned to convert 2.3 million natural gas domestic end users and 0.18 million existing CNG driven vehicles to using LPG. This could be a great initiative in transforming the transport sector of Bangladesh as LPG is considered to be good for the engines which reduce the maintenance costs of the vehicles. In addition, using LPG to run vehicles does not require frequent refilling like CNG, relieving the people from the menacing traffic jams as well. In order to provide a cushion and promote greater use of LPG in the transport sector, the government has plans to raise CNG prices by two-thirds of the current price.

A concerning fact adhering to the LPG market in Bangladesh is the fact that almost 80% of the total LPG market is import dependent while merely 20% is held by state-owned companies producing LPG locally. Thus, the private sector has a role to play in generating LPG locally which would not only keep LPG prices relatively low but would also reduce the dependence on LPG imports. LPG market development using indigenous energy inputs can also generate employment opportunities within the country which eventually could be translated into the social welfare of its people. More importantly, LPG market development locally can be highly effective in managing the rural demand for energy and can also attribute to poverty alleviation in those areas. The development of this market strongly hinges upon the improvement in the rural LPG distribution channels which would enhance the availability of LPG in the rural and semi-urban areas of the country. The demand for LPG is expected to experience a surge following the government's policies aimed at reducing natural gas shortage and its conservation for future uses. Thus, the LPG sector is viewed as a profitable avenue for private investors to invest funds for the development of the overall energy sector of Bangladesh.

5. KEY BARRIERS OF LNG AND LPG MARKETS IN BANGLADESH

Although LNG and LPG have immense prospects in dictating the energy diversification processes in Bangladesh, the development of the associated markets have traditionally been held back due to a number of constraints. For instance, poor energy infrastructure of Bangladesh has always acted as the major impediment to LNG imports in the country. A major drawback of LNG usage is the fact that it requires a health infrastructure for it to be accessible to the end users. Building land-based LNG terminals require huge quantity of open land at concessional rates for the terminal developers. Bangladesh, being a densely populated developing nation, has always been subject to a shortage of empty lands that can be used for LNG importing, storing and regasification purposes. An alternate solution to the demand for open land could be building floating LNG terminals. However, such offshore projects are subject to hefty investments and require technical expertise which unfortunately has been constraining LNG market development in Bangladesh. Moreover, inadequate deep sea ports for handling huge amount of LNG carriers is another major constraint that has contributed to the underdeveloped energy infrastructure hampering LNG market development in Bangladesh.

Besides poor energy infrastructure, the relative costs associated with LNG production and usage also been a major issue when it comes to large-scale LNG employment, especially for electricity generation purposes. The import cost of LNG for Bangladesh will be around USD 8 per million British thermal units and taking the regasification charges into consideration the total cost would sum up to around USD 11 per million British thermal units. However, the government is planning to use a pooling mechanism and subsidize LNG price making it available at USD 4-5 per million British thermal units for the end users. Nevertheless, even at this subsidized rate, the cost of LNG is way more than the cost of natural gas it is expected to replace. As a result, the use of relatively expensive LNG for electricity generation, in particular, would definitely have a cascading effect on the cost of electricity generation and would require revision of the bulk power tariffs. However, such increase in energy tariffs is always against public sentiment as it automatically reduces the non-energy expenditure of households and industries. In order to balance the difference in prices of imported LNG and conventional locally produce natural

gas, the government very recently has expressed its decision to increase per unit natural gas and CNG prices within the country, which sparked public oppositions and protests pressurizing the government to reconsider the price hike decision. Hence, the cost factor does act as a crucial barrier against adoption of LNG in the national energy framework of the country.

On the other hand, barriers upholding LPG market development are relatively less severe compared to those restricting development of the LNG market in Bangladesh. One of the main issues surrounding LPG usage is that it is a comparatively costlier energy option. At present, the price of non-subsidized LPG hovers around 1400 taka per 12.5kg with an additional 1500 taka for the LPG cylinder. When compared to the price of its alternatives, local natural gas at USD 2-3 per million British thermal units and high speed diesel at USD 24 per million British thermal units, the prospect of using LPG often gives second thoughts to the consumers which has a negative impact on its adoption in a wide scale all throughout the economy. However, keeping the associated benefits of LPG usage into consideration it is a matter of debate whether to go for this high price-trade off or not, for the greater interest of energy resource diversification in Bangladesh.

Moreover, the poor energy infrastructure of Bangladesh is not a huge issue for the development of the LPG market since a strong infrastructure is not a pre-requisite for LPG adoption in the energy sector. However, it does act as a bottleneck to meet the ever-growing demand for LPG in the country. Due to all the existing LPG import terminals situating near the port areas, equitable distribution of LPG across the entire country seems to be hampered. Thus, LPG coverage is insufficient and uneven in Bangladesh which tends to hamper its rural development in particular. For example, the Rangpur division in the country has relatively lower access to LPG compared to the other divisions mainly because of the absence of waterways leaving the expensive road transportation as an alternative. Furthermore, the drying up of water bodies in Bangladesh has also aggravated the constraints faced in distributing LPG to the rural areas of the country. As a consequence, LPG has been regarded as a less reliable source of energy due to the possibility of disruptions in its supply following transportation constraints.

Lack of operational efficiency is another concerning factor associated with LPG market in Bangladesh. This has been the scenario particularly due to lack of competition within the sector. At present only six private companies operate within the country which implies the insufficient amount of competition. In addition, the private companies are confined to only importing LPG with no involvement in producing LPG locally. The local supply of indigenous LPG is undertaken by a couple of state-owned companies in Bangladesh. Therefore, this lack of private intervention through investment in the domestic LPG market has had a negative impact on the sector's development and has also attributed to dependence on the high priced imported LPG. In the absence of any public assistance and funding, the high costs of LPG generation and distribution have deterred private institutions from entering the local LPG market as well. Thus, the absence of public-private collaborations in the country has unfortunately deferred the development of the LPG market to a major extent.

6. INTERNATIONAL LNG AND LPG MARKETS

LNG and LPG have penetrated the energy sectors in the developed world as well as some of the developing nations across the globe. Alternative fuels including LNG, LPG, CNG, etc. have made their ways into the global transport sector. According to a report published by the European Commission (2016) the aggregate transport sector accounts for more than a quarter of total energy usage worldwide and is also responsible for a little less than a quarter of total greenhouse gas emissions globally. Thus, the use of environmentally friendly liquefied gases in the form of LNG and LPG in the global transport sector has been a revolution in reducing greenhouse gas emissions all over the world. In between 2010 and 2015, there were 2% rises in the number of LNG and LPG powered vehicles around the world which clearly implies the growing trends in LNG and LPG adoption in both the developing and developed nations.

LPG, in particular, has emerged as a promising transport fuel in energy markets across China, India and Russia. LPG is a widely used source of cooking fuel in rural areas in India and recent development in the LPG market in the country has effectively reduced India's rural energy deficit. The magnitude of market penetration through LPG in the developed nations recently depicted a diminishing trend when compared to that in the developing countries which clearly implies that LPG is a preferable source of energy in developing countries in particular. Moreover, a clear shift in Asian LPG dynamics can be seen from the trends in LPG imports in some of the major Asian countries. Traditionally, Japan accounted for the lion's share in the total volume of LPG imports in the Asian region. From 2012 onwards, demand for LPG in Japan exhibited rising trends which tend to have slowed down in recent times. Moreover, statistical insights assert that China is most likely to overtake Japan in terms of LPG imports (Richardson, 2004). Chinese LPG imports reached a staggering 11.5 million tonnes by the end of 2015 and are expected to increase further by the end of the current fiscal year. Such a surge in LPG demand in China reflects effective implementation of the nation's policies that were aimed at reducing per capita carbon emissions in the country. LPG market development has also taken place in most of the West African nations. These countries have made the best possible use of their indigenous LPG resource base and have increased LPG usage all throughout the region. The governments' financial assistance in subsidizing the price of LPG enhanced the accessibility of this clean energy resource in those countries which not only met their energy demand but also helped the nations to maintain a harmony with the environment. It is to be mentioned that Nigeria is a net exporter of LPG in Africa. Statistical figures showed that Nigeria produces over 2 metric ton of LPG per annum of which 85% of the LPG is exported to different African countries (Ahmed, 2013). However, the figures are quite alarming in the sense that in spite of producing a huge quantity of LPG, the per capita LPG consumption in the country is very low compared to that in West African countries like Ghana and Senegal.

Similarly, LNG market development has also exhibited a promising trend worldwide. For instance, China has gone on to become the third largest importer of LNG in the world by the end of 2012 (Chen, 2013) surpassing the UK and Spain. It started its journey of importing LNG way back in 2006 with Australia being the first country to export LNG to China. Australia, Qatar and Indonesia are the three main countries from whom China imports LNG on a long-term basis. In addition, China also purchases LNG in spot markets from countries belonging to the Atlantic Basin. An encouraging aspect of the Chines LNG sector is the fact that ever since the first LNG shipment arrived from Australia in China in 2006, the Chinese government started providing incentives to local investors leading to large-scale investments in upstream LNG projects. Simultaneously, the domestic LNG industry was also brought under the Chinese government's assistance radar whereby mini-LNG generation plants were set up. LNG as an alternative transportation fuel was the main driver of the mini-LNG industry in China. Likewise, China, the prospects of LNG in India are promising enough to generate positive economies within the nation. Following the growing natural gas demand in the country, LNG imports are expected to reach around 140million standard cubic feet per day by the end of the fiscal year 2020. An increase in the number of LNG terminals and regasification units have immensely contributed to the rise the volume of LNG imports in India whereby the share of imported LNG in India's total domestic gas supply rose from a mere 1% in 2004 to almost 20% by the end of 2010. The strong energy infrastructure in this country ideally complemented LNG import activities and have contributed in terms of minimizing the gap between demand and supply of natural gas in India.

7. CONCLUSIONS AND POLICY RECOMMENDATIONS

Transition to use of LNG and LPG is one of the potential ways through which energy security in Bangladesh can be achieved (Amin *et al.*, 2017). Augmenting the energy market of Bangladesh through the incorporation of LNG in the national energy framework can be exemplary in mitigation of the nation's prolonged electricity crisis. It can also replace CNG and imported petroleum products in the transportation sector relieving the natural gas pressure in the country and at the same time keep carbon emissions at a manageable rate. Simultaneously, through

the provision of widespread access to clean cooking and heating solutions mainly via LPG, Bangladesh can resolve its domestic natural gas crisis and at the same time, it can safeguard the health of the consumers via the reduction in harmful gaseous emissions. In addition, LPG usage in the transport sector can curb the import bills arising from petroleum imports and at the same time release pressure from the ever-growing demand for CNG. Therefore, the strategy of enhancing the use of LPG and LNG within the economy is very much in line with the United Nation's Sustainable Development Goals (SDGs) by ensuring clean, affordable and sustainable access to energy resources worldwide.

Energy is considered to be a strategic input that attributes to socioeconomic security, food security, health security and environmental sustainability. Research reveals that the socioeconomic costs of burning fossil fuels across the developing world are enormous and devastating. For instance, it has been estimated that exposure to indoor air pollution from the combustion of fossil fuels causes around 4 million premature human deaths per year in developing countries across the globe. Moreover, the use of biomass for energy generation leads to environmental degradation through deforestation causing natural calamities like floods, especially in tropical countries like Bangladesh. Hence, keeping the huge prospects and economies of usage into consideration, a switch from the employment of traditional fuels to LNG and LPG would ideally improve the standard of living of the people of Bangladesh and would also help to attain the far-reaching social, economic and environmental benefits. However, in order to reap the complete benefits of using these two relatively eco-friendly energy sources, as alternative fuels, the concerned markets need to be developed properly. Moreover, favorable government regulations, improvement of infrastructure in port areas, awareness building and, most importantly, proper pricing of LPG and LNG are necessary to ensure effective energy diversification for resolving energy crisis in Bangladesh.

However, the barriers upholding potential penetration of LNG and LPG in the domestic energy market in Bangladesh need to be addressed carefully, leaving no stones unturned in resolving the challenges that lay ahead in overcoming the barriers. With respect to LNG market development in Bangladesh, it is recommended that the government engages in investment projects aimed at developing the energy infrastructure of the country. Although such projects are subject to huge financial injections, the potential benefits, in the long run, would outweigh the present costs via contributing to the nation's energy security through partial fuel diversification. The government can also provide incentives to private investors to do the same in order to build more LNG terminals and storage and regasification units both on and offshore. Furthermore, the government can gradually reallocate its subsidies from natural gas to imported LNG just to create a balance between their relative prices. Although the provision of energy subsidies is against efficient use of energy in the economy, such subsidy reallocation may actually generate benefits in the form of rapid fuel diversification in Bangladesh energy sector.

On the other hand, in order to promote greater use of LPG all throughout the country, the government of Bangladesh can encourage private investments necessary for local LPG generation which would gradually bring down the average per unit price of LPG and also lessen the dependence on foreign LPG. As a part of this price controlling policy, the government can provide concessional loans for local LPG generation projects rather than completely lifting the taxes and duties on LNG imports. This could be ideal in ensuring self-sufficiency in LPG production in the future which would further strengthen the nation’s energy security issues.

In addition to controlling the average price of LPG, the government can also invest in strengthening the LPG distributional channels so that all the divisions of the country have a more or less even access to LPG resources. This is ideally important for the rural areas of developing countries in particular that have traditionally been neglected in the form of inadequate energy supply which has restricted rural development to a major extent. A balance between rural and urban usage of LPG can, therefore, contribute towards minimization of the overall energy deficit in Bangladesh. Finally, public awareness regarding the safe use of LPG is another area that requires government intervention. LPG cylinder explosion is a common phenomenon in developing countries whereby inappropriate use of the LPG cylinder may trigger casualties. Thus, in order to resolve the safety problems, the

government can engage in holding workshops to disseminate proper knowledge with regard to the use of LPG, especially at the rural household level. Provided the government succeeds in overcoming the existing barriers associated with LNG and LPG employment within the economy, energy resource diversification in Bangladesh should not be a far-fetched phenomenon which would be effective in ensuring sustainability in its domestic energy supply.

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