

## **Problems and Prospects of LNG Terminal at Maheshkhali Island in Bangladesh**

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### **Abstract**

The main source of fuel & energy in Bangladesh is mainly natural gas and imported petroleum. Liquefied Natural Gas (LNG) could be the alternative energy to mitigate the recent fuel and energy crisis. The main theme of the present study is to assess the problems, prospects, and socio-economic role of LNG terminals on the fuel and energy sector in Bangladesh. Primary and secondary data sources are integrated to achieve the study's findings. Primary data was collected through direct field observation survey, questionnaire survey, focus group discussion (FGD), and expert opinion survey. To conduct the questionnaire survey, around 400 respondents were selected randomly from the study area during the months of November 2020 to October 2021. The problems regarding LNG import and operation by the LNG terminal are identified through the present study respectively; Unstable market price (26%), Corruption (17%), Proper legislation (16%), High tariff (16%), System loss (14%), and Governance and distribution (11%). There are several prospects are also found to mitigate gas scarcity in Bangladesh. The findings of the correlation matrix also demonstrated that a positive significant relationship is sustained between the LNG-oriented activities and socio-economic parameters for the study area.

**Keywords:** LNG Terminal, Maheshkhali, Island, Problems, Prospects

### **Introduction**

Liquefied Natural Gas (LNG) is the fastest-growing element in the global natural gas and fuel market. It also contributes an increasing share of trade. LNG production grows by 4.3% accounting for 15.5% of global gas consumption by 2030<sup>1</sup>. Bangladesh is facing both relatively high growth rates of the population with expanding economy and a deficiency in domestic fossil fuel energy. Growing population and expanding economies are the main causes of increasing energy demand. Natural gas is the most important indigenous source of energy that accounts for 75% of the commercial energy in Bangladesh<sup>2</sup>. About 28 gas fields have been discovered in Bangladesh.<sup>3</sup> The main source of fuel and energy in Bangladesh is mainly natural gas and imported petroleum. At present, the daily average gas production in Bangladesh is about 2300-2350 Million Standard Cubic Feet per Day (mscfd). National Gas Companies produce around 1050-1100 mscfd and the International Oil Company (IOCs) produces around

1200-1300 mscfd of the total production of gas<sup>4</sup>. Presently the produced gas is used in the Power sector, Fertilizer, Captive Electricity, Industry, CNG stations, Commercial, Tea Gardens and also in the Domestic sector. It is estimated that about 75% of power-oriented industries, Fertilizer companies, CNG Refueling stations, and power plants are run on natural gas<sup>3</sup>. Recently, the entire country is suffering from gas shortage. The availability of domestic primary fuel supply is getting so scarce that it is forcing severe measures like shutting down fertilizer factories, rationing gas supplies for households, CNG station transport uses and keeping installed power units inoperative. It is essential to minimize the difference between the demand and supply situation of gas in the country. Liquefied Natural Gas (LNG) could be the alternative energy to mitigate the recent fuel and energy crisis. To alleviate the crisis, the Government of Bangladesh had been decided to set up four land-based

LNG terminals and one or two Floating Storage and Re-gasification Units (FSRU) due to the additional 3500 mscfd of gas that will be needed in the upcoming years, especially for power generation and industrial purposes<sup>5</sup>.

The idea of transporting natural gas in a liquid state was first patented in May 1915 by Godfrey L. Cabot<sup>6</sup>. The attempt to realize this idea was re-energized in 1952 by Willard L. Morrison, followed by J.J. Henry in 1954 when they developed the Liquefied Methane Barges<sup>7</sup>. However, the idea of transporting liquid gas became a reality with the first LNG carrier, named *Suehiro Maru* with 150m<sup>3</sup> of LNG capacity, operated from 1962 until 1983 using an internal combustion engine as the prime mover<sup>6</sup>. The first steam turbine LNG vessel, the *Methane Princess* was the world's second LNG carrier, operating from 1964 until 1998 with an LNG capacity of 27,400 m<sup>3</sup><sup>8</sup>. Since then, the numbers, configurations, and sizes of LNG carriers have continued to increase.

The operation of LNG plants involves the extraction and transformation of natural resources with consequences for the environment and social conditions<sup>9</sup>.

In Bangladesh, the port facilities are very limited and especially for LNG vessels because of the higher requirement of draught. A plan has been taken to use FSRU near Moheshkhali Island where the required draught is available at about 5-6 km offshore of Moheshkhali coast. The mother vessel carrying LNG would be transferred to the FSRU which would be moored at about 5-6 km off-coast of Moheshkhali.<sup>3</sup> An offshore pipeline is installed from the FSRU and a delivery point and stationed on-shore at Moheshkhali Island. From the delivery point, a gas transmission pipeline of about 85-90 km is installed to bring the gas to the port city of Chattagram<sup>10</sup>. In Chattagram, it would be hooked up to the Karnaphully gas system and the gas would be supplied to the customers. As per the plan, initially, about 500 mscfd of gas would be supplied for which in total about 4 million tons of LNG would be

required annually.<sup>2</sup> LNG accounts for 30% of the world trade in gas, its export involves 18 countries, and 26 countries have re-gasification terminals<sup>11</sup>. Furthermore, in the last seven years, the number of exporting countries is increased by 40% and importers are increased by 70%<sup>11</sup>. First of all, the situation of LNG in the global market will be shortly overviewed. A major player in the market of short-term LNG sales (36% of total spot supplies) is Qatar, which is also the largest of the world's producers of liquefied gas and the second place is Nigeria with a 15% share of this market<sup>11</sup>. Also, important suppliers to the spot market are Trinidad and Tobago, Indonesia, Egypt, and Russia are also involved in spot trading LNG in 2015<sup>12</sup>.

Energy security is a concerning issue for all the countries in the world, as with modernization, the use of energy has been increasing rapidly and people's life and the national economy becoming dependent on the usage of energy<sup>13</sup>. So, to maintain a secure future, different initiatives are being taken in the energy sector all over the world. It is therefore essential to take steps to ensure necessary energy supplies and their proper distribution in Bangladesh to support steady socio-economic development. Islam and Muzemder<sup>2</sup> urged that Bangladesh will be faced a great challenge in providing energy for its huge population with limited electrification, energy shortage, poor management, and heavy reliance on a single primary energy resource. The energy demand will double today's level within the 2050s<sup>13</sup>. We can also give attention to another source like nuclear power which will be a great source of energy and the government should take well-thought-out development schemes to ensure that these basic needs are fulfilled as early as possible.

The Maheshkhali floating liquefied natural gas (LNG) terminal was developed offshore at Maheshkhali Island in the Bay of Bengal. It is the foremost LNG import terminal and is expected to help secure the future provision of energy in the country. Bangladesh is heavily dependent on natural gas for its energy

requirements due to limited hydro and wind resources, as well as a lack of available land for the development of solar projects. The country has been experiencing a severe scarcity of energy resources for many years, with demand exceeding 5 Billion Cubic Meters (BCF) in a year. These shortages are having a noticeable effect on its energy, water, and transport sectors. Additionally, the existing natural gas reserves are forecast to exhaust by 2031, despite being anticipated to comprise more than 15 Trillion Cubic Feet (TCF)<sup>14</sup>. Bangladesh is expected to face an energy crisis as no new fields would discover by that period. Petrobangla projected the construction of the new terminal to address this shortage and enable the importation of natural gas into the country. The proposal was initially made in 2010, though finding a company willing to implement the project took approximately six years<sup>15</sup>. The Maheshkhali floating LNG terminal is included floating storage and re-gasification unit (FSRU) a subsea buoy system, and a subsea pipeline, which is connected the terminal to an onshore pipeline system. This floating LNG is an integral component to ensuring the vitality of Bangladesh's energy future. The Maheshkhali Floating LNG provides much-needed clean energy to promote power reliability, industrial development, and job creation in a sustainable manner. This floating LNG Terminal is the world's first fully integrated turnkey floating LNG terminal whereby all services are provided under a single contract by a single provider. This LNG terminal enables Petrobangla to procure LNG from international gas markets which will further complement and enhance its ability to reliably use the country's domestic natural gas reserves. The Maheshkhali Floating LNG terminal project is a result of the collaboration between Excelebrate Energy (USA), Petrobangla, and International Finance Corporation (IFC), which is mandated to provide and arrange the required financing for the terminal.

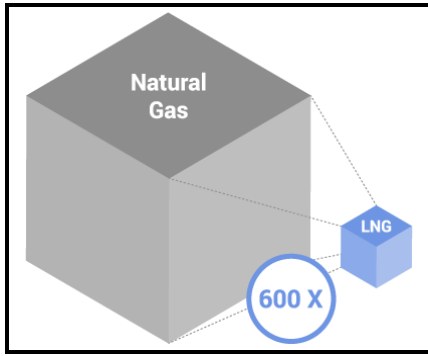
To accomplish vision 2041 and sustainable development goals (SDGs) particularly SDGs Goal-7: 'Secure access to affordable, reliable, sustainable and

*modern energy for everyone by 2030 and to minimize the demand-supply gap*', the Government has invigorated its effort to enhance gas production along with initiatives to import significant quantities of LNG<sup>3</sup>. Consequently, two separate terminal use agreements (TUA) have been signed with Excelebrate Energy Bangladesh Limited (EEBL) and Summit LNG Terminal Company Private Ltd. to install 2 floating storage and regasification unit (FSRU) at Maheshkhali approximately 90 km. south of Chattogram for supplying 500 mscfd of LNG<sup>3</sup>. The first ever FSRU (by EEBL) was commissioned in August 2018 and the second FSRU (by Summit) was commissioned in April 2019. In the above circumstances, it is an important task to know the problems, prospects, and socio-economic role of the LNG terminal at Maheshkhali Island to mitigate gas scarcity in Bangladesh.

#### **What is LNG?**

Liquefied Natural Gas or LNG is natural gas (predominantly; Methane- CH<sub>4</sub>) that has been converted to liquid form for ease of storage or transport. It is cooled to -260 °F (-162 °C) changing it from a gas into a liquid that is 1/600th of its original volume.<sup>5</sup> After arriving at its destination LNG is warmed to return it to its gaseous state and delivered to natural gas customers through local pipelines. It is odorless, colorless, non-toxic, and non-corrosive. LNG achieves a higher reduction in volume than compressed natural gas (CNG). LNG is not stored under high pressure and is not explosive. Although a large amount of energy is stored in LNG, it cannot be released rapidly enough into the open environment to cause the pressures associated with an explosion. LNG vapors (methane) mixed with air are not explosive in an unconfined environment.

Natural gas is a fossil fuel that has been created by organic material deposited and buried in the earth millions of years ago. Crude oil and natural gas constitute types of fossil fuel known as "Hydrocarbons" because these fuels contain chemical combinations of hydrogen and carbon atoms.



**Figure 1.** Volume concentration of LNG<sup>6</sup>.

The chemical composition of natural gas is a function of the gas source and type of processing. It is a mixture of methane, ethane, propane, and butane with small amounts of heavier hydrocarbons and some impurities, notably nitrogen and complex sulphur compounds, water, carbon dioxide, and Hydrogen Sulphide (H<sub>2</sub>SO<sub>4</sub>) which may exist in the feed gas but are removed before liquefaction<sup>16</sup>. The different types of chemical compositions (with percentages) of LNG which can help to identify the mixture of LNG are shown in the following Table 1.

*Aim and objectives*

The main aim of the present study is to address the problems and prospects of LNG terminal and its impacts on local socioeconomic development. To achieve the goal, some specific objectives had been taken as follows;

- i. To find out the problems and prospects of the LNG terminal at Maheshkhali Island in Bangladesh.
  - ii. To explore the socio-economic impacts of LNG terminal at Maheshkhali Island in Bangladesh;
- and

- iii. To find out the relationship between LNG Terminal-oriented activities and socio-economic developments in the study area.

*Hypothesis*

The hypothesis is using a proposition that can be put to a test to determine its validity and may seem to a contrary or in with common sense<sup>18</sup>. A null hypothesis (*H<sub>0</sub>*) was formulated for the present study to know the relationships between the LNG terminal-oriented activities and socio-economic development in the study area. The formulated null hypothesis is taken as follows:

*H<sub>0</sub>*= ‘There is no relationship between LNG Terminal and socio-economic activities in the study area’

**Materials and Methods**

*Study area*

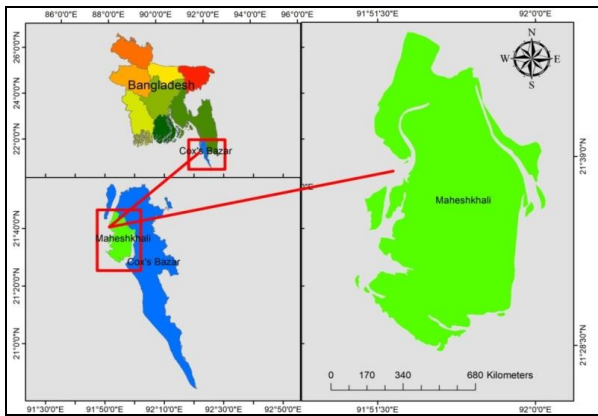
The first LNG terminal is designed as floating storage and re-gasification unit (FSRU) near Maheshkhali Island about 5-6 km offshore of the Maheshkhali coast. The Maheshkhali Island is the only hilly natural Island situated on the Bay of Bengal under Cox’s Bazar district in Bangladesh (Map 1 and Figure-1). It is located between 21°33’N to 21°55’N latitudes and 91°57’E to 91°95’E longitude and covers an area of about 362 sq. km<sup>19</sup>. The total population of the Island is 219520 where males constitute 53.13%, and females are 46.87% of the population<sup>20</sup>.

**Table 1:** Different types of chemical compositions of LNG

Name of the Chemical	Formula	Low	High
Methane	CH <sub>4</sub>	87%	99%
Ethane	C <sub>2</sub> H <sub>6</sub>	<1%	10%
Propane	C <sub>2</sub> H <sub>8</sub>	1%	5%
Butane	C <sub>4</sub> H <sub>10</sub>	0.005%	1%
Nitrogen	N <sub>2</sub>	0.1%	1%

Source: US Department of Energy<sup>17</sup>.

Map 1. Location of Maheshkhali in the context of Bangladesh



Source: The base map was collected from a LANDSAT Satellite image and prepared by GIS Arc View.

[Courtesy: Alam,<sup>19</sup>]

*Sources and collection procedures of data*

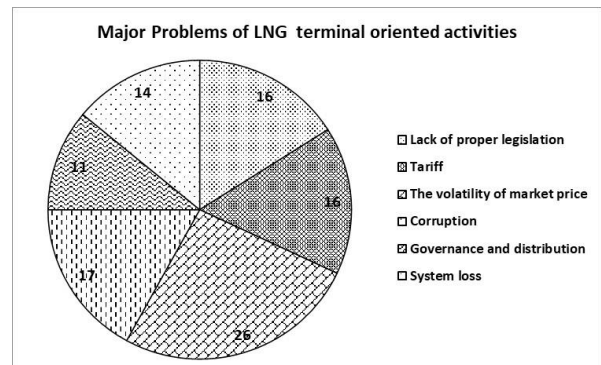
The present study was carried out based on the combination of primary and secondary data which were collected from different sources. In the present study, primary data were collected from (i) Direct field observation, (ii) Focus Group Discussion (FGD), (iii) Questionnaire survey, and (iv) Expert opinion survey. There are five times direct field observations were conducted to find out the overall condition and general scenario of the study area. There are about 400 questionnaires have been conducted to know the socioeconomic impacts of the LNG terminal. All the stakeholders were chosen by using stratified random sampling (local people, concerned officials, distributors, users, technical persons, etc.). To conduct the research questionnaires were constructed with both the open and closed types of questions along with pre-coded and coded manner. Two FGDs have been conducted to cross the information and data from a questionnaire survey. The FGD groups were chosen from LNG distributor, officials, and LNG exporters. To know the prospects a set of concerned LNG experts’ and technical persons’ opinion survey was conducted. The experts were chosen from Prominent Fuel experts (Namely; Dr. M. Tamim, Professor of BUET, and Dr. M. Shamsul Alam, Advisor and Expert of CAB). Secondary data were collected from intensive literature

survey, previous and present gas and LNG-oriented data, books, journals, National gas company offices records, related GOs and NGOs reports, and various published and unpublished materials from different researchers regarding the LNG-oriented fields. The whole gathering of data is analyzed sequentially. The collected data from questionnaires were coded, edited, and converted (Qualitative to Quantitative) according to the methods of<sup>21</sup>. The collected data and information have been analyzed with the help of required computer software namely; Microsoft Excel and SPSS. The map was prepared with the help of ARC GIS. The statistical data have been presented in tabular and graphical form to make it easy and understandable. All the citations, notes and references are used in the present study according to following format of the Chittagong University Journal of Biological Sciences.

**Results and Discussion**

*Problems of LNG Terminal*

Though the demand for LNG is increasing worldwide because it is environment-friendly clean energy but several local and operational problems, and threats are identified regarding LNG terminal handling in Bangladesh. Lack of Proper Legislation, Tariff, Volatility of market price, Corruption, Governance and distribution, and system losses are identified as the major problems of LNG import and terminal handling for Maheshkhali FSRU. The identified major problems of LNG import and terminal handling at Maheshkhali are shown in the following Figure 2.



**Figure 2.** Major problems of imported LNG in Bangladesh  
[Source: Questionnaire Survey, 2021]

### *Lack of Proper Legislation*

It is observed from the present survey that 16% of respondents argued that due to proper legislation, the imported LNG sector would be non-profitable (Fig.2). Proper legislation regarding LNG import and operation in the coastal areas of Bangladesh must be needed for sustainable resource and energy management. The principal environmental, public safety, and security laws, regulations, standards, and issues for sighting, design, construction, and operation of LNG import terminals have to take under proper legislation. Without proper rules and regulations regarding LNG could create several problems. Prominent fuel expert Professor M. Tamim also expressed his opinion that due to a lack of proper laws and guidelines for imported LNG, our national fuel scarcity and industrial development may be interrupted.

### *Tariff*

It is observed from the present survey that 16% of respondents believed that due to the proper tariff system, the LNG sector will be un-commercial (Fig.2). Since imported LNG is expensive and blended tariff is projected expensive. Bangladesh Energy Regulatory Commission (BERC) organized a hearing on tariff hike rationale from six distribution and transmission companies and Petrobangla. The tariff rise proposed by gas distribution companies are 206% in power, 372% in fertilizer, 93% in Industry, 73% in the Tea estate, 66% in Captive power, and 25% in CNG station and these proposals are incredibly higher than current tariff.<sup>22</sup> Tariff hikes can create a serious problem in the local LNG market.

### *The volatility of the market price*

The market price of LNG should be in the range of general people; otherwise, it may create suffering. It is observed from the present survey that a significant portion (26%) of respondents urged that due to unstable market prices the imported LNG sector might not be popular (Fig.2). It is treated as the prime problematic

issue for the mass consumer in Bangladesh. Sajid<sup>23</sup> reported in 'The Business Standard' regarding this issue where he stated "At present Bangladesh has kept half of its floating storage and regasification Units (FSRU) of LNG terminal because of lower input due to price Volatility.

### *Corruption*

It is observed from the present survey that (17%) of respondents believed that due corruption in various stages of the imported LNG sector will be created another problem in the future (Fig.2). Bangladesh is well-known for corruption in various sectors. The energy sector is also touched by corruption heavily. Dr. M. Shamsul Alam, Advisor of the Bangladesh Consumers Association (CAB), has given his opinion as "TITAS officials illegally provided connections to a large number of consumers by taking bribes". He also expressed that the gas sector was facing a similar disaster to the banking sector in Bangladesh.

### *Governance and distribution*

It is observed from the present survey that (11%) of respondents believed that due to lack of proper governance and distribution of pipelines, this sector may not be sustained (Fig.2). Uncertain distribution policy of LNG may be created problems for the export-oriented industry. Although Petrobangla is not directly involved with the operation & Distribution Company for LNG Petrobangla claimed TK. 0.23 per cubic meter (CM) for LNG is irrelevant and unjustified for Petrobangla as an operation & Distribution Company of Energy in Bangladesh.<sup>24</sup> It is also estimated that GTCL margin TK. 0.42 per CM can be considered an LNG project that requires huge network infrastructure improvement work.<sup>25</sup> Good governance is also required to operate the LNG market and business in Bangladesh.

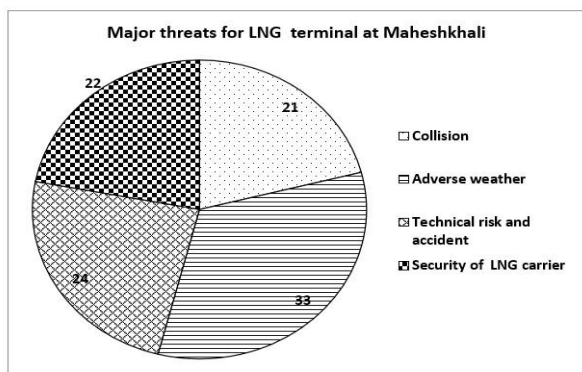
### *System loss*

It is observed from the present survey that 14% of respondents assumed that due to system loss, the LNG sector may not be profitable (Fig.2). The technical fault at the sub-sea gas pipeline caused fiscal loss before

commissioning, therefore, to handle this new technology, technical skill development of distribution companies and Petrobangla need priority. Due to proper technical skills, the LNG terminal can be stopped in the future. CPD<sup>26</sup> pointed out that the system loss of imported LNG and its operation are responsible for huge subsidy on the fuel sector in Bangladesh.

#### *Probable threats for Maheshkhali LNG Terminal*

There are some possible threats are identified through a questionnaire survey for imported LNG at Maheshkhali LNG Terminal as shown in the following Figure 3.



**Figure 3.** Threats for LNG terminal at Maheshkhali  
[Source: Questionnaire Survey, 2021]

#### *Collision*

It is observed from the present survey that 21% of respondents believed that collision would be a threat to LNG terminal operation (Figure 3). Collision incidents can lead to the deformation of the LNG containment and the release of LNG can occur in the future. Effects of this incident can adversely affect human life, the biotic, and the aquatic environment. The following two collisions are the most common incidents in LNG terminal where there is a high risk of loss of containment.

##### *i. Collision with another vessel*

The collision of LNG vessels is a probable high risk due to the release of liquid into the separation section (between the tank and the ship's hull). A large breach can result in a direct release into the water. The spill floating on the water will be warm, causing increased evaporation of the LNG. The expansion of the spill across the water is caused by the river flow and the wind.

##### *ii. Collision with jetty*

A collision with the quayside usually occurs during the maneuvering. The speed level of LNG carriers during contact with a Jetty is also depending on the high and low tides of the ocean coast.

#### *Adverse weather*

It is observed from the present study that 33% of respondents argued that adverse weather at Cox's Bazar during the summer season would be a great threat to LNG terminal operations (Figure 3). Bangladesh has already been taken to build additional floating liquefied natural gas (LNG) import terminals in favor of land-based stations. Adverse weather is making it difficult to operate the country's sole floating storage and re-gasification unit (FSRU). Imam<sup>25</sup> mentioned that from April to August every year the LNG terminal at Maheshkhali near the city of Cox's Bazar and its start-up may be delayed by several months due to technical problems and bad weather. Nicholas Browne, director of Asia-Pacific gas and LNG also expressed that Bangladesh does have extreme weather conditions during the monsoon period. So it is quite clear that adverse weather can affect the Maheshkhali FSRU which is located 9 km. away from the coast and hence it could be a devastating threat for LNG carriers during massive cyclones.

#### *Technical risks or accidents*

It is observed from the present survey that 24% of respondents argued that risk or accidents during the operation of LNG would be a possible threat to the Maheshkhali LNG terminal (Figure 3). It is noted that LNG is volatile and very cold and its vapor is flammable and potentially explosive. The risk was attention largely after the massive accident that occurred on 20<sup>th</sup> October 1944 in Cleveland where 128 people were died by the conflagration after an LNG tank collapsed<sup>27</sup>. LNG is flammable fuel that can spread and evaporates. For a large spill of LNG on water, an LNG vapor cloud may drift several miles from the site of a spill under stable atmospheric conditions if it

encounters no ignition sources enrooted. Since LNG facilities are often cited in or near densely populated areas, the results of a very large spill could be catastrophic. So, there is a potential risk and threat of LNG accidents in the host community.

*Security of LNG Carrier*

It is also observed from the present survey that 22% of respondents believed that the security of LNG carriers would be another possible threat to the Maheshkhali LNG terminal (Figure 3). Alam (2017) also found that LNG carrier and their route security is a threat to LNG carriers in Bangladesh.

*Prospects of LNG Terminal*

In Bangladesh, natural gas is the most important indigenous source of energy that accounts for 75% of the commercial energy of the country<sup>2</sup>. 28 gas fields have been discovered with two gas fields located in an offshore area in Bangladesh<sup>3</sup>. The country has been dogged by serious gas shortages for a long time now that crippled several industries. Some CNG filling stations facing losses and owners are thinking of shutting down but distribution authorities are assuring that the crisis will mitigate in near future. Recently, a significant number of CNG filling stations are going to convert into LPG filling stations. To reduce the dependency on natural gas, alternative energy resources must be explored. Although there are several problems and the recent global increase in gas prices is a reality for LNG import but some prospects are also mentionable regarding imported LNG. The probable prospects of the LNG terminal are given in the following Table 2.

*i. Mitigation of the gas shortage problem*

It is observed from the above Table 2 that the majority portion of respondents (86%) urged that the Maheshkhali LNG Terminal will be able to mitigate the recent gas shortage problem. It is mentionable that long queues in front of the compressed natural gas (CNG) filling stations amply demonstrate how severe the gas shortage is in Chittagong as well as in Bangladesh. Moreover, gas supply shortage coupled with low pressure is seriously affecting cooking in households and hampering industrial output in the recent period. According to Petrobangla, the current demand for gas across the country is 3,300 mscfd while the production is around 2,700 mscfd<sup>3</sup>. For this reason, several residential areas across the country face the gas crisis during winter. However, the authorities (Petrobangla) believe that the gas crisis could be overcome within the next two years when the supply would jump by 37% riding on imports of LNG<sup>22</sup>. The government of Bangladesh believes the LNG price will be affordable and remain stable after the Russia and Ukraine war.

*ii. Introduce LNG terminal-oriented activities /business.*

It is observed from the above table 2 that a significant portion of respondents (61%) believed that several LNG-oriented activities and businesses are growing up after the establishment of the LNG terminal at Maheshkhali. Local land use and settlement pattern are changing, small businesses are introduced and tourism activities are increasing due to the Maheshkhali LNG terminal. Alam<sup>19</sup> also found that small businesses and enterprises are established by imported LNG at Maheshkhali. It is also

**Table 2:** Prospects of LNG terminal at Maheshkhali Island

Prospect of LNG	Opinions (%)*	Rank
i. Mitigation of the gas shortage problem	86	1
ii. Introduce LNG terminal-oriented activities/business	61	2
iii. Improvement of socio-economic condition	55	3
iv. Acceleration of economic and industrial growth	54	4
v. Supply of LNG to other big cities to ensure power & energy	37	5

Source: Questionnaire Survey, 2021] \*Multiple answers are considered



**Table 3:** Beneficial sector of local community by the LNG terminal

Opinion	(In %)	Opinion on benefit	Opinions (%*)
Yes	76	Increased income opportunities for the local community	61
		Improved safety and security within the neighborhood	34
		Increased quality of life for women	41
		Created new opportunities for businesses/shops	62
		Created job opportunities in the local community	19
		Improved local road network and infrastructures	78
		Others	10
No	24		

[Source: Questionnaire Survey, 2021]; \* Multiple answers are considered

observed by the FGD that local land is increased and landowners are going to be benefited from the Maheshkhali LNG terminal.

### iii. Improvement of socio-economic condition

It is observed from the above table 2 that a significant portion of respondents (55%) believed that the local socio-economic condition with infrastructures will be improved due to LNG terminal-oriented activities at Maheshkhali Island. It is also observed from the field survey and FGD that several partial complete/*semi-Kacha* roads are converted into complete/*pacca* due to the terminal at Maheshkhali. The local people are also benefitted through increasing land prices, Jetty oriented settlement, and health and communication services after the establishment of the LNG at Maheshkhali terminal.

### Local community benefit from LNG the Terminal

It is observed from the present study through a questionnaire survey that the majority of respondents (76%) have given their opinions in favor of positive

community benefits from the LNG terminal-oriented activities in their local community. The summarized opinions and beneficial sectors in the local community by the LNG-oriented activities are shown in the following Table 3.

It may be pointed out from the above Table-3 that local people are going to be benefited from LNG terminals involving themselves in various socio-economic activities. Therefore; their income and living standard with quality will be increased by the LNG-oriented activities at Maheshkhali Island.

### Skill development of the local community by the LNG terminal

It is observed from the present study through a questionnaire survey that the majority of respondents (77%) urged with human resources quality of the local community will progress by the LNG terminal-oriented activities in the study area (Table 4). The summarized opinions on the skill development of the local

**Table 4:** Opinions on Skill Development of Local People by the LNG Terminal

Opinions on skill development increase			
Opinion	(in %)	The sector of skill development	Opinions (in %*)
Yes	77	Technical education	24
		Computer skills	40
		Electrical skills	56
		Mechanical skills	51
		Business skills	70
		Women skills	30
		Others	10
No	23		

[Source: Questionnaire Survey, 2021];

\* Multiple answers are considered

community through LNG terminal-oriented activities at Maheshkhali are shown in the following Table 4.

It is observed from above Table 4 that 70% of people will be benefited from business skill development through the LNG terminal-oriented activities at Maheshkhali. It may be pointed out from the above table-4 that local people will be benefited through the development of their skills in electrical (56%), Mechanical (51%), computer (40%), and technical education (24%) by LNG terminal through involving themselves in various skill development activities. Therefore; their human resource development and progresses with quality will be increased through the LNG-oriented activities at Maheshkhali Island.

*Capability to improve livelihood conditions by the LNG terminal*

It may be also stated through the findings of the study that the majority of respondents (78%) urged with the LNG terminal is capable to improve their livelihood condition (Table 5). The summarized opinions on the capability to improve livelihood conditions by the LNG terminal at Maheshkhali are shown in the following Table 5.

It is observed from the above Table 5 that a significant portion (45%) of respondents believed the livelihood condition of the local people might be improved to a ‘moderate’ level. The result also indicated that 30% believed ‘high’ level improvement will be changed of livelihood conditions by the LNG terminal at Maheshkhali (Table 5). On the other hand, only 10% of respondents believed on ‘low’ level changes may be occurred due to LNG terminal-oriented activities in the study area (Table 5).

*iv. Acceleration of economic and industrial growth*

It is observed from the above Table 2 that a significant portion of respondents (54%) believed that the local and regional industrial sector with economic growth will be accelerated through the LNG terminal at Maheshkhali. Murshed and Amin<sup>11</sup> also mentioned that sustainable industrial production and growth may be increased through the imported LNG terminal at Maheshkhali Island.

*v. Supply of LNG to other big city to ensure power & energy*

It is observed from above Table 2 that (37%) of respondents urged that the Maheshkhali LNG terminal might be capable to supply LNG to other big city like;

**Table 5:** Capability of LNG terminal to improve local livelihood

Opinions on skill capability		Capability to improve livelihood conditions with a level	
Opinion	(in %)	Improvement level of livelihood	Opinions (in %*)
Yes	78	Significant /high	30
		Moderate	45
		Low	10
		No idea	15
No	22	Total	100

[Source: Questionnaire Survey, 2021];

**Table 6:** Capability of LNG terminal to reduce fuel scarcity

Opinion on capability		Capability of LNG terminal to reduce of fuel scarcity	
Opinion	(in %)	Level of demand fulfill	Opinions (in %)
Yes	79	high	30
		Moderate	40
		Low	16
		No idea	14
No	21	Total	100

[Source: Questionnaire Survey, 2021];

Chattogram and Dhaka to ensure the power & energy sector in Bangladesh. It is also observed from the present study that the majority of respondents (79%) believed that the Maheshkhali LNG terminal might be capable to mitigate partially the huge demand for fuel in Bangladesh (Table 6). The summarized respondents' opinions on the capability with level to reduce fuel scarcity by the Maheshkhali LNG terminal is shown in the following Table 6.

It is observed from above Table 6 that about (40%) of respondents believed the capability of mitigation of fuel scarcity through the Maheshkhali LNG terminal might be improved to a 'moderate' level. The result also indicated that 30% of respondents believed on 'high' level improvement by the Maheshkhali LNG terminal (Table 6). On the other hand, only 16% of respondents believed on 'low' level changes may be occurred at the Maheshkhali LNG terminal (Table 6). Murshed and Amin<sup>11</sup> also mentioned that imported LNG could be ideal to ensure sufficient LPG production in Bangladesh.

*Relationships between LNG oriented activities and socioeconomic development*

*Variables used for correlation coefficient in the present study*

There are some selected parameters of socio-economic condition are used to explore the impacts on the socio-economic role of LNG terminals are examined through computing the correlation matrix. The variables are considered to analyze the correlation coefficient for the present study regarding the formulated null hypothesis is shown in the following Table 7.

*Relationship between LNG oriented activities and socio-economic Development in the study area*

The socio-economic impacts of LNG are considered as the dependent variable and LNG oriented activities are considered the independent variable to test the concerned null hypothesis. The relationships between the LNG oriented activities and socio-economic development variables are examined by testing the null hypothesis with the help of the following equation.

**Table 7:** Variables for correlation coefficient to explore the relationships between LNG-oriented activities and socioeconomic development

Factors of variables	Parameters of variables
Socio-economic impacts of LNG Terminal	Social impacts
	Economic impacts
	Occupation impacts
	Political impacts
	Transport and communication impacts

[Source: Questionnaire survey, 2021]

**Table 8:** Correlation coefficient values between independent and dependent variables

Independent Variable	Dependent variables	Computed value of 'r'	Tabulated value of 'r' at 60 degrees of freedom	
			at 5% level	at 1% level
LNG terminal-oriented activities	Social impacts	0.477**		
	Economic impacts	0.466**		
	Occupational impacts	0.433**	0.211	0.295
	Political impacts	0.241*		
	Impacts on local transport and communication	0.395**		

[Source: Questionnaire survey, 2021]

Notes; \* = Significant at 0.05 level of probability; \*\* = significant at 0.01 level of probability with one tailed, and 'r' = Parsons' Correlation Index

The equation for the calculation of the correlation matrix

$$r = \frac{\sum(x - \bar{x})(y - \bar{y})}{\sqrt{\sum(x - \bar{x})^2 \sum(y - \bar{y})^2}}$$

Where,

- 'r'= Correlation index
- x= Independent variables
- y= Dependent variables

Source: Islam<sup>21</sup>

It is observed from the above Table 8 that the calculated values of the correlation coefficient 'r' regarding the socio-economic impacts is 0.477 on social, economic (0.466), occupational (0.433), political (0.241), local transport and communications (0.395) are found respectively in the study area. The findings are indicating that the calculated values are higher than the tabulated values (Table 8). So, the concerned null hypothesis is rejected and the relationships between the above independent and dependent variables are positively significant. So, the above findings also demonstrated that a positive significant relationship is sustained between the LNG oriented activities and socio-economic development (such as; Social, Economic, occupational, Political, Local transport & communication) in the study area.

## Conclusion

The use of LNG in Bangladesh is yet to make its way forward despite measures taken to introduce LNG in the national energy policy of the country. Following the acute shortage in the supply of indigenous natural gas, the government in 2010 made up its mind to develop the infrastructure necessary to cater to LNG import. 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 makes 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 a 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. Transitioning to the use of LNG and LPG is one of the potential ways through which energy security in Bangladesh can be achieved. Augmenting the energy market of Bangladesh through the incorporation of LNG in the national energy framework can be exemplary in the 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 keeping 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.

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