STUDY OF THE POTENTIAL OF LNG FUELED SHIP BUNKERING SYSTEM IN BANGLADESH

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ABSTRACT

The use of Liquefied Natural Gas (LNG) as a marine fuel is growing in the maritime industry. This propulsion technology is getting attention due to the features sustainability, emission control, ECA zones, etc. Already, a number of LNG fueled ships are running and more are in order. Besides, the number of LNG-fueled ships are increasing. Chittagong port is the most significant port of Bangladesh. Matarbari will join in near future with some special features with mother vessel handling capacity which will reduce the use of Sri Lanka and Singapore as hub. Chittagong and Matarbari port will be going to handle some of the LNG fueled ships in future. Building an LNG refueling station can be a timely decision for LNG-fueled ships. Very few ports in South-East Asia have LNG refueling facilities are, Singapore, Kochi (India), Yokohama (Japan), Busan (South Korea), and Zhousan (China). In this research, how reliable the LNG bunkering system will be from the perspective of Bangladesh is highlighted. Various aspects are considered such as, trading with ECA areas, advantage of geographical locations, compatibility of ports, technical and operational facts, etc. The study can be used to create an LNG bunkering facility in Bangladesh in future.

Keywords: LNG, ECA, IMO, Bunkering.

1. INTRODUCTION

The world is fully dependent on maritime freight trade for transporting products in bulk. In 2020, about 10.6 billion metric tons of product will be transported in the sea [5]. Around 80% of global trade in volume and 70% of global trade by value are carried by sea and are handled by ports worldwide. According to projections by the International Transport Forum (ITF), an intergovernmental think tank, global demand for transport will continue to grow dramatically over the next three decades, with global freight demand expected to triple by 2050 [8].

LNG is a liquid form of natural gas that is done through reducing the temperature of natural gas to -162 degree Celsius. The volume of LNG is 600 times less than the same amount of natural gas at room temperatures [9]. The world is going to use a safer fuel for the shipping industry that will be more efficient and safe for mankind. Especially, restrictions on the emission rate for the greenhouse effect as well as environmental impact. Heavy fuel oil is responsible for high emission of SOx. Three options are presented to comply with IMO 2020 Sulphur cap which are to establish SOX scrubber, using fuels with low Sulphur and use LNG as the fuel [12]. Ships profiles need to be more accurate using the compliance method that must be identified to help the stakeholders to address the Sulphur cap of IMO 2020 [5]. LNG has higher hydrogen content in molecules as compared with HFO/MDO which causes CO2 emissions reduction by 30% [2].

Number of LNG fueled ships is now increasing in an eye catching amount. About 251 LNG fueled ships are operational at sea and 403 are in the order which will come for trading soon [1]. These vessels will require bunkering facilities around the world. The reserves of LNG are higher than oil which is an important factor to consider LNG as a safer fuel.

Bangladesh has export import trade with the countries that are designated as ECA zones. The countries of Baltic Sea region, North Sea region, US and Caribbean Sea region, Pacific and Atlantic sea areas of Canada and the US are included in the ECA zones. Those countries have strong emission regulations and the ships that visit those areas are inspected for lower emission. Thus the ships in those areas are going towards LNG fueling gradually.

The location of Bangladesh can be an advantage for the LNG bunkering facility. In Asia, already 4 ports have LNG bunkering facilities. This number will increase in the near future. There are almost 52 ports in the world that have LNG bunkering facilities where most of them are operational and some of them are
under construction. [11] An LNG terminal near the port increases the viability of an LNG bunkering facility. Bangladesh has some LNG terminal projects in different regions that will accelerate the thinking about LNG bunkering facilities. Bangladesh has a reserve of natural gas on shore and has a big possibility of getting natural gas from our offshore areas. According to the report by BP, the Reserves-Production Ratio of gas is higher than oil in the world. [6]

2. METHODOLOGY

This research is conducted to show the potential of an LNG bunkering facility in Bangladesh. For the analysis, two of the major ports of Bangladesh are considered. One is the ‘Chittagong Port’ and the other is ‘Matarbari Port.’ Chittagong port is located in the South-East part of Bangladesh with the latitude and longitude of 22.3091°N, 91.8018°E. Matarbari port is also situated in the South-East part of Bangladesh but more south from Chittagong port and near the longest sea beach Cox’s Bazar with the latitude and longitude of 21.6914°N, 91.8590°E. Some parameters are considered to attain the decision. The considerations are taken about the export-import volume of Bangladesh with the countries of ECA zones, future expansion of ECA zones, the environmental issues, future increase of LNG fueled vessels, port compatibility, port geography etc. For every case, the present scenario is shown for the parameters with respect to Bangladesh and globally. This is done through representing the studies and data for every aspects. The data regarding these considerations for Bangladesh is demonstrated concurrently. Later, a qualitative analysis is done from the perspective of Bangladesh for every considering parameters. Figure and tables are demonstrated to represent the data. The similarities, dissimilarities, advantages, scopes, potentialities etc. are shown after comparing with existing global data. The conclusions are drawn based on the analysis. Some of the data are about forecasts and are taken from different sources. The data about export and import are not converted into present value.

3. POTENTIALITY FOR BANGLADESH

3.1 ECA Zones and It's Future Expansion

IMO has declared the ECA zones where the emission content is strongly controlled. The maximum sulfur content permeable in the ECA zone is 0.1% m/m. The current list of ECA regions are shown in Table 1. To control the emissions in these regions, LNG fueled ships have proven as most advantageous. Bangladesh has export and import trading with these countries for a long term. Ships which move around these routes have to abide by the emission rules according to IMO. Currently a number of LNG fueled and dual fuel vessels (Marine diesel oil and LNG) are running in these areas. Ships which have routes between ECA zones and Bangladesh or South East Asia are the concern for Bangladesh regarding LNG bunkering. To support those vessels with this type of bunkering, LNG bunkering facility will be required in future.

Table: 1: Implementation Date, regions & control content of ECAs (According to IMO)

<table>
<thead>
<tr>
<th>ECAs</th>
<th>Regions</th>
<th>Implementation Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltic Sea Area, SOx</td>
<td>Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Sweden</td>
<td>19 May, 2006</td>
</tr>
<tr>
<td>Baltic Sea Area, NOx</td>
<td>Baltic Area, NOx</td>
<td>1 January, 2021</td>
</tr>
<tr>
<td>North Sea Area, SOx</td>
<td>Germany, Denmark, Belgium, France, Netherlands</td>
<td>22 November, 2007</td>
</tr>
<tr>
<td>North Sea Area, NOx</td>
<td>North American Area, NOx</td>
<td>1 January, 2021</td>
</tr>
<tr>
<td>North American Area, SOx</td>
<td>North American Area, SOx</td>
<td>1 August, 2012</td>
</tr>
<tr>
<td>U.S Caribbean Sea Area, SOx</td>
<td>U.S Caribbean Sea Area, SOx</td>
<td>1 January, 2014</td>
</tr>
<tr>
<td>U.S Caribbean Sea Area, NOx</td>
<td>U.S Caribbean Sea Area, NOx</td>
<td>1 January, 2016</td>
</tr>
<tr>
<td>Newly Included</td>
<td>China, South Korea</td>
<td>1 January, 2022</td>
</tr>
</tbody>
</table>

It is seen from Table 1, in 2022, China and South Korea have declared as ECA zones. ECA zones are still expanding and will expand in future. This indicates that LNG ships will grow massively in the near future. To become compatible in the shipping sector, creating facilities for LNG fueled ships will be mandatory for Bangladesh.

3.2 Export and Import with ECA Zone Countries

Seaports were always significant for the transport of goods, money, and cultural exchange. This cost-effective form of mass transportation has made the
growth of global trade, business, and industry. Therefore, seaports still serving as the hub of commerce and economic growth, which secures the prosperity of the nation. Economy of Bangladesh greatly depends on export-import, and the largest part of total trades have done via waterway. Therefore, maritime transportation and its continuous development has become a foremost duty for Bangladesh. Most of the countries in the ECA zone are European and American who are the main importer of Bangladeshi goods. Top 10 importers from Bangladesh are the U.S.A, Germany, UK, Spain, France, Italy, India, Japan, Canada and Australia. Most of them are under ECA zones. Specific sulfur restrictions are currently applicable in the European Union, Turkey, Iceland, California, Sydney, China, etc. [10] South Korea also has restrictions that are under application now. LNG fueled vessels are one of the most suitable fuels in those ECA areas.

The direct trading from Bangladesh to all of those countries under the ECA zones is not established yet. Currently, Sri Lanka and Singapore are used as the trading hubs. But in future this trading route will be directly established from Bangladesh as the deep sea port facility in Bangladesh has already come into service (Matarbari). Most of that vessels that will come from ECA zones either will be LNG fueled or dual fueled. The economic development of a country like Bangladesh is highly dependent on the export and import growth. A trend of growing the export of Bangladesh is seen after the study of previous 5 years and a visualization is shown in Figure 1 which indicates an overall positive impact.

The air pollution is reduced and the amount of particulate matter is decreased with the use of LNG, which are penetrated deeply into the lung. Global warming has been a serious issue for the world for many years. Reducing the production of greenhouse gases to combat this global warming is now a concern for the world. From this perspective, LNG is better

Figure 1: Growth rate of export for recent years

![Figure 1: Growth rate of export for recent years](image1.png)

It has exported in 2021-2022 fiscal year around 204,654.6 million USD only in the ECA zones. Six of the top 10 exporting nations are listed in the ECA region, which are certainly another major factor. The export rate from Bangladesh to some of these countries is shown in the Figure 2. A direct export route from Bangladesh to these countries will make it inevitable using LNG fueled ships and bunkering in this region. Hence, a good number of LNG fueled vessels will have to cross our region in future for continuous trade.

Figure 2: (a) Export shares (2019-2021) with principle countries included ECA zones

![Figure 2: (a) Export shares (2019-2021) with principle countries included ECA zones](image2.png)

Figure 2: (b) Import shares (2019-2021) with principle countries included ECA zones

These ships will need refueling facilities, but still there isn’t any LNG bunkering terminal yet in Bangladesh. These ships will be going to refuel from the nearest terminal, some majors are Cochin Port (India), Ningbo Zhoushan Port (China), Busan Port (South Korea) & Jurong Port (Singapore). Therefore, LNG bunkering terminal in the ports of Bangladesh can be a milestone.

3.3 Environmental Issues

Strong restrictions have been imposed on the emission of Sulphur (SO\textsubscript{2}), Nitrogen (NO\textsubscript{x}), Carbon products (CO\textsubscript{2}, CO), Methane (CH\textsubscript{4}), etc by the International Maritime Organization (IMO). According to ‘IMO 2020’, the maximum limit of Sulphur emission outside the ECA (Emission Control Area) is 0.5% m/m (mass by mass) from the previous limit of 3.5%. LNG-fueled ships have reduced emissions of SO\textsubscript{2}, NO\textsubscript{x}, CO\textsubscript{2}, and other gases that are hazardous to the environment. Liquefied Natural Gas (LNG) is an environment friendly fuel that produces less amount of CO\textsubscript{2} than coal or other conventional marine fuel oil. Also, the emission of NO\textsubscript{x} and PM (Particulate Matter) significantly decreased in the dual-fuel mode. [11]

The air pollution is reduced and the amount of particulate matter is decreased with the use of LNG, which are penetrated deeply into the lung. Global warming has been a serious issue for the world for many years. Reducing the production of greenhouse gases to combat this global warming is now a concern for the world. From this perspective, LNG is better
than other marine fuels. Emissions of many gases can be reduced using LNG fueled ships, shown in Table 2 [6]. Also, LNG is called a clean energy source for this reduced emission characteristics.

Table 2: Gas emission reduction resulting from operating with different emission control systems compared to the use of LNG according to F. Burel, R. Taccani, and N. Zuliani [1]

<table>
<thead>
<tr>
<th>Abatement Technology/ Measure</th>
<th>Emission Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SOx</td>
</tr>
<tr>
<td>Basic internal engine modifications for 2 strokes, slow speed only</td>
<td>0</td>
</tr>
<tr>
<td>Advanced internal engine modifications</td>
<td>0</td>
</tr>
<tr>
<td>Direct water injection</td>
<td>0</td>
</tr>
<tr>
<td>Humid air motors</td>
<td>0</td>
</tr>
<tr>
<td>Exhaust gas recirculation + scrubbing</td>
<td>-93</td>
</tr>
<tr>
<td>Selective catalytic reduction (2.7% S residual oil fuel)</td>
<td>0</td>
</tr>
<tr>
<td>Sea water scrubbing</td>
<td>-75</td>
</tr>
<tr>
<td>Fuel switching (from 2.7% S to 1.5% S HFO)</td>
<td>-44</td>
</tr>
<tr>
<td>Fuel switching (from 2.7% &gt;1.5% S HFO)</td>
<td>-81</td>
</tr>
<tr>
<td>Low S marine diesel (from .5 to &gt;.1%S)</td>
<td>-80</td>
</tr>
<tr>
<td>Liquefied Natural Gas (LNG)</td>
<td>-90</td>
</tr>
</tbody>
</table>

LNG compared to HFO, results in some significant advantages like:

a) In dual-fuel combustion engines, NOx emissions are reduced by approximately 85%.

b) LNG doesn’t contain sulfur and the particulate production is very low.

In the near future, LNG will be more appreciable and suggested fuel oil. In that time, LNG bunkering facilities will be required almost everywhere which need to be considered by Bangladesh.

3.4 Vessel and Port Compatibility

LNG has been used as fuel in LNG carriers for a protracted time. But for the time demand, all kinds of ships are starting to use LNG as fuel. Some LNG fueled ships are compared with the port compatibility in Figure 3. Vessel length is another issue for LNG bunkering depending on the port facility. There may have restrictions on the bunkering site for the maximum vessel length. The selection of location is thus important. Chittagong and Matarbari Port have restrictions on the draft and length for vessels. Here, some data are shown in the Table 3 regarding draft and length restriction.

Table 3: Maximum permissible length and draft of ships that can enter into the port

<table>
<thead>
<tr>
<th>Port Name</th>
<th>Maximum Permissible Length</th>
<th>Maximum Permissible Draft</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chittagong Port</td>
<td>190m</td>
<td>9.5m</td>
</tr>
<tr>
<td>Matarbari Port</td>
<td>338m (10,000 TEU’s Container Ship)</td>
<td>16m</td>
</tr>
</tbody>
</table>

Figure 3: (a) Ships draft restrictions in ports of Bangladesh and comparison with some existing LNG fueled ships

Figure 3: (b) Ships and length restrictions in ports of Bangladesh and comparison with some existing LNG fueled ships

For the vessels that will take the bunkers, a mooring system is required. Adequate fendering is another considerable issue. For the safe bunkering operation, a certain distance need to be maintained by the vessels in the port. The mooring facility is required in the port for sustaining the ship in any bad conditions.
weather conditions and wind. The freeboard of the receiver vessel and bunkering vessel need to be maintained in such condition that the bunker hose can reach the receiving vessel's pipeline. This can be either with the help of a crane or other means. The spill containment system development is needed to protect the vessel in case of any spillage of LNG. Proper communication is required for a safe bunkering operation in ports. A comparison between the facilities of the port length and draft restrictions with some existing LNG fueled ships from the perspective of Bangladeshi port is given in the Figure 3.

From Clarkson Research show, it is seen that currently 147 ports around the world have the LNG bunkering facility and this will reach 200 in 2024. [12] This is a serious indicator of growing LNG fueled ships and LNG bunkering facilities. Ports of Bangladesh also have to be a part of this community in near future.

3.5 Future Increase of LNG Fueled vessel and LNG Terminal Facility

About 251 LNG fueled ships are operational at sea and more than 400 are in the construction. There are also a lot of vessels running with dual fuels. They are either built with an LNG fuel facility or later retrofits to convert them into an LNG fueled facility. There are many driving forces behind this increase in numbers of LNG fueled ships. This number will not remain the same or decrease in future. It will increase due to many reasons including IMO regulations and environmental issues. This growing number of ships will need bunkering around the world. Obviously Bangladesh will handle a certain portion of those ships in its port. LNG bunkering facilities in the ports of Bangladesh will help these ships to use the ports for bunkering.

Another considerable thing is the LNG terminal facility. LNG terminal facilities work as the reservoir of LNG and also some terminals have liquefaction facilities to convert natural gas into LNG. In Bangladesh, several LNG bunkering facilities are going to be built. Already two units of FSRU (Floating storage and regasification unit) are operational in the Matarbari area. Though these cannot contain or reserve LNG, it shows a potential for Bangladesh as an LNG using nation. One LNG terminal construction will start in the future in Matarbari. There are several are in plan and under study i.e. Kuakata, Bholu, etc. These LNG terminals will be the major support for the LNG bunkering facility in Bangladesh.

3.6 Port Geography and Location

Bangladesh is the largest delta in the world. Bay of Bengal and Andaman Sea covers most of the sea areas south of this delta. Mainly, the coast of India and Myanmar is located in this region. Some LNG bunkering facility have been built up around the Asia and South-East Asia in recent tears. Some of them are Cochin Port (India), Ningbo Zhoushan Port (China), Busan Port (South Korea), Jurong Port (Singapore), etc. They handle the mother vessels where Matarbari port has the same characteristics. Some of the characteristics of the ports with LNG Bunkering facility are shown in Figure 4 and 5. Though the cargo handling of these ports are more than Bangladeshi ports, but by the time the export and import of Bangladesh will expand significantly. Thus the cargo handling in Bangladesh ports will increase significantly.

Some European ports have less draft compared than Bangladeshi ports such as Hammerfest (7.7m), Port Fourchon (7.6m), Ennshafen (7m), Hirtshals (9m), Talinn (10.7m), etc. Also, some of them have less cargo handling capacity compared to Bangladeshi ports.

As there has no ports in the region near the Myanmar coast, only Singapore or Cochin Port are the only LNG bunkering source. Many ports are adopting this bunkering system to become compatible with future. Building this LNG bunkering facility in Chittagong and Matarbari can take Bangladesh in leading position in LNG bunkering in future in this region. If a good pricing can be offered to the international LNG fueled vessels, then it will also be beneficial from the economic perspective as well.
Bangladesh is gradually making progress in the shipbuilding and shipbuilding industries. Fuel is one of the driving forces in this sector. Natural gas is an important alternative fuel that is expected to drive the future due to its influential features. When compared to conventional Heavy Fuel Oils, the use of LNG for ship propulsion reduces NOx, SOx, and CO2 emissions. Climate change and the IMO regulations are the very important driving force for adopting an LNG-fueled propulsion system. The reduction of emissions is obviously needed. Thus LNG fueled propulsion system is a highly considerable technology at this time.

The trade with the countries of ECA zones made the necessity of LNG-fueled propulsion as high importance for Bangladesh. LNG bunkering facility is required to support LNG-fueled ships in the future. The ports of Bangladesh are compatible to accommodate LNG-fueled ships. Some existing ships are compared to validate this factor. The length and draft of the ships are considered to check the compatibility. It is seen from this comparison that, the ports are able to facilitate these ships.

Another factor is the future plan for LNG terminals. These terminals can be used as the supply of LNG for the bunkering system. A sustainable LNG supply can be made by using these terminals. This factor is also an indicator to reveal the possibility of the LNG bunkering system in Bangladesh.

Future possibilities of extraction of natural gas from offshore areas have made a door for Bangladesh for an LNG bunkering facility. The vast ocean of Bangladesh is not exploited yet. The high chance of finding natural gas and other resources can be a blessing for a secured source for the raw material of LNG (Natural gas). In comparison to other countries based on geographical location, it will also be lucrative for Bangladesh. Geographical location sometimes has a big impact on taking decisions. Finally, this is seen from the study that, LNG fuel has a promising prospectus in the maritime industry. It can be considered by the concerned authority of Bangladesh.

5. CONCLUSIONS

After this study about the LNG Bunkering prospects of Bangladesh, some conclusions can be drawn:

- The future expansion of ECA zones will provoke the world to use LNG as marine fuel strongly. The demand for LNG bunkering facilities will then increase and Bangladesh can grab that opportunity.
- The main importers from Bangladesh are the American and European countries when many of which are declared as ECA zones. To trade with those countries by direct shipping in the future LNG fueled ships will be required and LNG bunkering facility will boost this trading.
- Already the world is on the hardline for environmental pollution and marine pollution is one of them. Many regulations have already been implemented and will come in the future to reduce this pollution. LNG fueled propulsion will help those regulations and the number of LNG fueled ships will be sky high. LNG Bunkering facility will be required everywhere including Bangladesh.
- Proposed LNG terminal facilities and current LNG facility (FSRU) will be a major helping source of LNG bunkering facility. Most of the infrastructural support for the LNG bunkering facility can be achieved once these projects are done.
- Ports of Bangladesh are compatible for accessing LNG fueled ships. Length and draft allows most of the existing LNG fueled ships to enter the ports. Taking this increasing number of LNG fueled vessels in future, LNG bunkering facilities can be built in these ports.
- The port geography characteristics compared to other Asian ports with LNG facilities shows that it is possible for Bangladesh to build such a facility of LNG bunkering.

6. REFERENCES


Figure 5: Location and Information of Asian Ports with LNG Facilities


