IGEM Young Persons Paper Competition

Far East District Section

LNG as Fuel for Ships in Yangtze River

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Abstract

As natural gas consumption in China grows rapidly, LNG is fast gaining focus especially as a form of clean fuel in the transportation sector. For ships, using LNG as fuel is technologically viable yet beneficial to both the shipping industry and the environment.

The author of this paper is involved in a project promoting the use of LNG as fuel for ships in Yangtze River. In this paper, the author shares the background of the project and the details of the upcoming demonstration run in which a LNG-fuelled ship and LNG bunkering solution will be prepared.
Background

With growing focus on developing inland waterway transport, the promise of Chinese Government to cut greenhouse gas emission and increasing supply of LNG, LNG bunkering for ships in inland waterways has become the latest application of LNG being investigated in China.

Yangtze River is the longest and busiest river in China. The large number of ships there, especially those with large tonnage, high utilization rate and hence high fuel consumption, represent a huge potential market for LNG bunkering.

Photo 1: Yangtze River; the places mentioned in this paper are labeled by boxes

In 2010, a project promoting the use of LNG as fuel for ships in Yangtze River was started by ECO Environmental Investments Limited (ECO). As a member of the project team, I participate in managing the project, which include research of market and technology available, identifying tasks and how goals will be achieved, making reports and suggestions to the company.
LNG-fuelled Ships: Proven Technology

The world’s first LNG-fuelled ferry-Glutra entered service in 2000 in Norway [1]. Following the good experience in operating Glutra, more LNG-fuelled ships are ordered and now the number has increased to 20 (LNG tanker excluded).

Advantages of Using LNG as Fuel for Ships

According to DNV (Det Norske Veritas), using LNG as fuel for ships can cut CO\(_2\) or greenhouse gas emission by 20-25\%, SO\(_x\) and particulates by 100\% and NO\(_x\) by 85-90\% compared to heavy fuel oil (HFO) [2]. Similar figures are expected when comparing LNG to diesel.

Furthermore, by switching from diesel to LNG, the fuel cost can be lowered since LNG has a lower price than diesel in China.

The Demonstration Run

A demonstration run is being prepared through which we aim to show the economical and environmental advantages of using LNG as fuel for ships, which is new to China. A ship will be converted to use LNG as fuel and LNG bunkering solution will be provided. We hope to convince the shipping industry of the benefits of using LNG, and also to provide a case for all concerned authorities to study and work out relevant rules, enabling the widespread use of LNG as fuel for ship in Yangtze River and other inland waterways in the future.

Getting the First LNG-fuelled Ship

A 3000T bulk carrier, “Bao Tong Jiang 1” (Photo 2), sailing between Wuhan and Shanghai along the Yangtze River, is chosen to be converted. The converted ship will become the first LNG-fuelled ship classed to CCS (China Classification Society) in the inland waterways of China.
A cooperative relation is formed with CSIC (China Shipbuilding Industry Corporation, one the largest ship building and repairing group in China) who provides technical support for the conversion. The two diesel engines in use are to be replaced by two dual fuel engines which uses small amount of diesel to ignite natural gas and can operate in diesel in case the supply of LNG is interrupted. A 30m$^3$ LNG tank, providing range to cover a round-trip between Wuhan and Shanghai (over 2000km), will be installed. As a result, the cargo space will decrease by 50 cubic meters. Fortunately, the loss in income can be fully offset by the reduction in fuel cost.

The following (Table 1) is an estimation of the net annual saving after conversion in the case of “Bao Tong Jiang 1”:

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price of Diesel</td>
<td>RMB 7,700 per tonne</td>
</tr>
<tr>
<td>Price of LNG</td>
<td>RMB 6,000 per tonne</td>
</tr>
<tr>
<td>Fuel consumption per month before conversion</td>
<td>Diesel: 30 tonnes</td>
</tr>
<tr>
<td>Fuel consumption per month after conversion</td>
<td>Diesel: 9 tonnes, LNG: 21 tonnes</td>
</tr>
<tr>
<td>Saving per month</td>
<td>RMB 35,700</td>
</tr>
<tr>
<td>Loss in income per month (due to reduced cargo room)</td>
<td>RMB 10,000</td>
</tr>
<tr>
<td>Net Annual Saving</td>
<td>RMB 308,400</td>
</tr>
<tr>
<td>Exchange rate: 100 RMB = 9.38 GBP</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1: Estimation of the net annual saving after conversion**
As shown above, switching from diesel to LNG lowers the fuel cost significantly, which in turns increase the profit for the shipping industry.

Moreover, CCS will be involved in the approval of design, certification of dual fuel engines and LNG tank, ensuring the converted ship meets the safety and performance requirement of relevant guidelines.

The cost of conversion is high as research and development, and also replacement of two engines are involved. In the future, ships can be built as LNG-fuelled so that the extra capital investment on using LNG as fuel can be significantly lowered and the payback period can be much shortened.

**LNG Bunkering**

A cost-effective LNG bunkering solution is needed to bunker an estimated 21 tonnes of LNG to “Bao Tong Jiang 1” every month. Furthermore, the solution should be reassuring to ship owners and also have the potential to be developed to meet greater demand of LNG bunkering in the future.

The source of LNG supply is first chosen. ECO is running a liquefaction plant in Jincheng, Shanxi Province (Photo 3), which produces LCBM (Liquefied Coal Bed Methane, which can be used as LNG). LCBM can be transported by LNG trailers to the bunkering stations near the Yangtze River.

Photo 3: ECO LCBM Plant, Jincheng, Shanxi Province
A LNG bunkering barge (Figure 1), providing a storage capacity of 100 cubic meters at the bunkering station, is being designed. This is similar to the solution adopted by diesel bunkering station, which is expected to give the ship owners sense of assurance.

![Figure 1: Drawing of LNG Bunkering Barge](image)

Solution to bridge the source of LNG (LNG trailer on land) and the bunkering station (LNG bunkering barge on water) is critical (Figure 2). Existing diesel bunkering stations (Photo 5) in Yangtze River have been studied. Most of them are not easily accessible by road transport and the diesel is supplied by tankers.
Other piers handling dangerous goods (e.g. LPG and other liquid chemicals) along the Yangtze River are specially built with pipelines, often with length over 100 meters due to the nature of Yangtze River, to transfer the goods (Photo 6). Due to the cryogenic nature of LNG and the fact that a relatively small amount of LNG is bunkered each time, this will not be adopted as high cost of pre-cooling involved and the large amount of boil off gas generated.

Eventually, two piers are found in Wuhan (Photo 7, 8) and Nantong (Photo 9), where a LNG trailer can get very close to the LNG bunkering barge. LNG can be first offloaded to and stored at the LNG bunkering barge, and then transferred to the ship to be bunkered by pump. Detailed flow of LNG bunkering is to be worked out and authorization for LNG bunkering is needed.
In the future, as the demand for LNG bunkering grows, small scale LNG tanker (1000-5000 m³) should be employed to transport LNG from LNG terminal along the sea coast to Yangtze River. This will also widen the choice of location for setting up bunkering stations as the LNG supply from land is no longer needed.

Photos 7 & 8: Pier, Wuhan, Hubei Province

Photo 9: Pier, Nantong, Jiangsu Province
Conclusion

LNG is an environmentally friendly yet economical alternative to diesel as the fuel for ships. Using LNG as fuel for ships represents no major technological obstacles but there are still a lot of limitations to be overcome as the project proceeds.

Preparations for the demonstration run are on the way. We will continue to work in collaboration with the shipping industry, ship building companies and the concerned authorities. The successful running of the converted ship and the LNG bunkering station will help to make the widespread use of LNG as fuel for ships in Yangtze River a reality.
References:

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[2] The age of LNG is here;
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