



Analysis of the Motive for the Use of LNG-Powered Ships in the Yangtze River Basin

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ABSTRACT: The clean green fuels generally recognized presently mainly include LPG, CNG and LNG, all of which hardly pollute water body and atmospheric environment during burning and are widely applied to shipping industry accordingly. Therefore, this paper carries out analyses on the inevitability of the wide application of LNG-powered ships from global energy source structure, economic demands for shipping and formulation of relevant international conventions; secondly analyses on domestic relevant policies about LNG-powered ship to promote its wide application in inland river of Yangtze River, and finally discussions on the use situation of LNG-powered ship in inland river basins of China in recent years under the impulsion of various factors.

1 INTRODUCTION

In order to respond to the decisive deployment of the State Council about building the Yangtze River Economic Zone relying on the Yangtze River golden waterway, the construction of Yangtze River waterway stays in a stable development stage. Yangtze River, as the first inland river golden waterway with freight volume ranking the first all over the world, undertakes the turnover of inland river waterway cargoes in China. In 2013, the inland river freight volume was 1.855 billion tons and cargo turnover up to 704.4 billion tons via Yangtze River, respectively covering 55% and 49%^① of the nationwide waterway freight volume. With the increase of cargo turnover, oily water and air contaminants resulted from ships also rise unavoidably and ships at ports of Yangtze River centralize comparatively, and the total discharge of oily water and aerial pollutant is extremely considerable as well. Therefore, it is extremely important to seek for a clean energy source to reduce the pollution to water body and air.

2 Change of global energy source structure

Because of excessive exploitation, petroleum is suffering from the challenge of increasing deficiency. According to the BP world energy source statistics (2013), the global petroleum reserves which has been ascertained is up to 168.79 billion barrels, which will only meet 53.3 years of global

production at the current exploitation speed. Recently, the occurrence of shale gas, tight oil, super-deep underwater petroleum and renewable energy sources has changed the global energy source structure, so the fuel energy source is never limited to petroleum any longer, gaseous fuel (natural gas), renewable energy sources and unconventional fossil fuel cover a greater proportion of energy source consumption, which therefore reduces the dependence of ships on petroleum greatly.

In 2013, the global natural gas reserves was 185.7tcm which had been ascertained, which was sufficient to meet 55.1 years of global production based on the current exploitation speed. In the Middle East and the Central and South America Region, there were the maximum and minimum natural reserves which had been ascertained, respectively covering 43.2% and 4.1% of the global total reserves^②. The natural gas reserves totaled 15.2tcm ascertained in the Asia-Pacific region, only covering 8.2% of the global total reserves, additionally the proportion of reserves to production (R/P) was lower, so the natural gas for daily life and production still relied on heavy-buying LNG for satisfaction in this region. The import volume of LNG was up to 238.1bcm in the Asia-Pacific region in 2013, covering 70% of global LNG imported, it was the largest LNG import region all over the world, thereinto, the import volumes of LNG in China, Japan and Korea were respectively 24.5bcm,



119bcm and 54.2bcm[®]. The prediction result of BP outlook 2035 shows China will be the second largest LNG import country in the train of Japan (13Bcf/d), with import volume up to 12Bcf/d.

Table 1: Natural Gas Distributions in China, Asia-Pacific region and all over the world

Natural gas	Proved reserves	Production	Consumption	R/P ratio
China	3.3tcm	117.1bcm	161.6bcm	28
Total Asia Pacific	15.2tcm	489bcm	639.2bcm	31.1
Total world	185.7tcm	3369.9bcm	3347.6bcm	55.1

Source: BP statistical review of world energy June 2014

The exploitation of natural gas has changed the global energy source structure and become a motive for rapid development of LNG-powered ships at home and abroad, while the Asia-Pacific region still depends on import of a plenty of LNG to meet the energy source demands. Shipping industry, as one of the main industries of energy source consumption, drives the development of liquefied natural gas (LNG), which is an inevitable demand for shipping development.

3 Inherent requirement for shipping economy

3.1 Environmental protection property of LNG fuel

3.1.1 Reduction of air pollution via LNG fuel

For the purpose of reducing shipping cost, a ship owner always selects a heavy fuel oil with comparatively lower price as ship driving fuel. Such heavy fuel oil contains a lot of bitumen, carbon, sulfur and metal compounds, which inevitably generate multiple atmospheric pollutants during burning. According to statistics, carbon dioxides, sulfur oxides and nitrogen oxides annually discharged from ships cover 6%, 20% and 30% of the global total discharge amount respectively[®]. The impact of ship pollutants to ports and quality of air along rivers, it is extremely important to search for a clean energy source as ship-driving fuel. Natural gas, with methane as main ingredient, only generates a little CO₂ and nitrogen oxides with few sulfur oxides during sufficient burning, so it is widely known and popularized in the shipping industry, instead of ship fuel.

3.1.2 Reduction of oil pollution via LNG fuel

With the improvement of shipping conditions and the increase of tonnage of ships in Yangtze River waterway, the power of mechanical equipment rises accordingly, especially the application of large-

power diesel engine to a ship incurs that the oil content in water at the ship bilge increases as well. If the bilge water is treated improperly and drained out of the shipboard, the water body will be polluted seriously. Moreover, there are more sensitive resources within Yangtze River economic zone where the self-cleaning capacity of the water body is weaker, the sensitive areas include the most upstream Dianchi Lake, Erhai Lake, Lugu Lake and other lakes and reservoirs in Yunnan Province; the most downstream Taihu Lake, Hangjiahu Lake as well as the North-south Grand Canal region, etc. Consequently, the optimal method is to popularize LNG ships and take water lubrication technology instead of the traditional lubrication if completely getting rid of oil pollution and atmosphere pollution from ship.

3.2 Economical efficiency of LNG fuel

From the economic efficiency, the price of LNG on the current market is up to about 3/4 of the diesel oil, the price of natural gas per cubic meter equals to about that of a liter of diesel oil, if burning is available according to the LNG-diesel oil proportion of 7:3, the cost of ship after using LNG reduces by about 25%[®]. In accordance with the analyses in “Discussion on the Application of LNG to Inland Waterway Field of China” (Zhou Shumin), a 3000t cargo ship perennially sailing from Wuhan to Shanghai can save fuel expense up to 445 thousand Yuan every year after using double fuels including LNG and diesel oil, and such ship can recover its cost within a year besides the construction expense of 500,000 Yuan. Accordingly, in comparison with diesel oil powered ship, LNG-powered ship is economical soundly

3.3 Gas supply guarantee of LNG fuel

Due to the uneven distribution of natural gas all over the world, various regions need to rely on the import and export of natural gas to keep demands balanced, which therefore motivates the establishment of LNG receiving stations all over the world. Relevant statistics reveal that by the end of 2013, the number of domestic LNG gas stations had increased to more than 2000, and it is predicted that there will be an increase of more than 10000 domestic LNG filling stations from 2015 to 2020. In terms of the guarantee of liquefied natural gas supply, natural gas supply facilities are widely distributed to meet the regional demands for liquefied natural gas.

Comprehensively considering the natural gas's environmental protection, economy efficiency, natural gas supply guarantee and other reasons, the use of a liquefied natural gas ship can effectively improve the economic benefits of the ship operation.



Therefore, the popularization of LNG ships can greatly meet the inherent requirements for the shipping economy.

4 Promotion of the Convention on the International Maritime Organization

4.1 Promotion of MARPOL supplementary provision VI

The International Maritime Organization (IMO) passed the MARPOL supplementary provision VI in July 2011, which raises the standards for emission of ship's nitrogen oxides (NOx) and sulfur oxides (SOx). The Convention requires that the sulfur content of ship fuels must be less than 0.5% by 2020; for those ships entering Baltic Sea, the North Sea and the coastal waters of North America and Caribbean sea where emission control areas (ECA) are established, the sulfur content must be less than 0.1% by 2015^⑦.

For NOx emission standards, the 66th session of Marine Environment Protection Committee (MEPC) explicitly indicated the NOx TierIII standard would be implemented for all the ships entering the ECAs of North America and Caribbean Sea in America since January 1, 2016; for new emission control areas (NECA) designated in future, the Committee stipulates: ships constructed on or after the day when a new ECA is designated, or on the date later than the specified in the amendment of ECA or later (the later date is chosen) should conform to the TierIII standard.

4.2 Promotion of international gas fueled ship safety rules

In order to reduce the pollution of SOx, NOx, CO2 and suspended particulates (PM2.5, etc.) emitted by gas fueled ships to the environment, IMO held the first meeting of "Cargo and Container Transportation Committee" (CCC) in London from September 8, 2014 to September 12, 2014, where the Rules for Safety of the International Gas Fueled Ships (the IGF rules, hereinafter referred to as "the rules") were reviewed and finalized, which were passed on the 95th Maritime Safety Committee of the International Maritime Organization (IMO MSC95) and will take effect on January 1, 2017. The rules are designed to establish mandatory provisions (including monitoring provisions) for the systematic arrangement, installation, and testing of machinery and equipment used for the gas fueled ship, in order to become the basis for the design, construction and use of such ship.

The raise of emission standards for ship NOx and SOx in MARPOL Supplementary Provision VI and the formulation of IGF rules incur that the application of ordinary fuel vessels to the shipping

industry falls into a dilemma, which therefore accelerates the transformation speed of ships taking LNG as driving fuel.

5 Driving of national policies

5.1 The latest regulations regarding the use of LNG-powered ships in inland waters

In order to promote the safe use of the LNG fuel ships in inland rivers, only in December 2014 did China Maritime Bureau issue three provisions on LNG-powered ship:

1) The Safety Supervision and Management Regulations on LNG Fuel Ships in Inland Rivers aims to supervise and manage inland river LNG-powered ships sailing, anchoring, operating and engaging in inland river traffic safety activities in inland navigable waters of the people's Republic of China;

2) The Notice Of Relevant Items On Promoting the Application Of Liquefied Natural Gas As Ship Fuel proposes the inspection certificate and pilot requirements for the application of LNG fuel to inland river ships and definitely prescribes the design and reconstruction requirements for ships and ship safety management;

3) Provisional Rules for Safety Supervision and Management on Water Liquefied Natural Gas Filling Stations proposes the establishment and site selection requirements for filling stations, advocates on the management on the safety and pollution prevention of fuel ships and stipulates the emergency response procedures for filling stations.

5.2 The latest regulations regarding the use of LNG-powered ships in the Yangtze River

The rapid growth and utilization of shale gas in the world has a great impact on China, which motivates the popularization and application of fuel ships in inland waters, lakes and reservoirs. In 2014, the State Council issued The State Council's Guidance on Promotion of the Development of the Yangtze River Economic Zone by Right of the Golden Channel, to create a green energy source industry zone along the Yangtze River, construct state-level demonstration zones for the comprehensive development of shale gas such as Changning-Weiyuan in Sichuan Province, the north parts of Yunnan and Guizhou, Fuling in Chongqing etc, and also steadily push forward the construction of coastal liquefied natural gas receiving stations, so as to strictly control and govern water pollution in the Yangtze River.

On November 18, 2014, the Ministry of transport publicized the List of the First Batch of Pilot Demonstration Projects on the Application of LNG to



Water Transportation Industry, in which pilot projects in the Yangtze Basin include:

1) The comprehensive LNG pilot project for backbone ships of Sinotrans & CSC Holdings Co., Ltd along the trunk line of the Yangtze River: it is proposed to build two inland river LNG-powered ships which are applied to the main waterway of the Yangtze River, construct LNG filling station and LNG loading/unloading dock at the supporting pilot of Huanggang, Hubei Province, as well as onshore water/land LNG filling station at the pilot site of Yichang, Hubei Province.

2) Sinopec's "oil and gas combination" pontoon style LNG filling station construction pilot project along the trunk line of the Yangtze River: it is proposed to build two pontoon style LNG filling stations with "oil and gas combination";

3) Onshore LNG filling station and LNG transshipment station pilot project of ENN Energy Holdings Limited along the middle-lower reaches of the Yangtze River: it is proposed to construct an onshore LNG filling station at on the trunk line pilot of the Yangtze River, research and bring forward LNG filling station service standards for ships along the trunk line of the Yangtze River.

6 The latest use of LNG-powered ship

GL DNV data show that the global LNG-powered ships will reach nearly 1800 in 2020. In the next three years, 37 LNG-powered ships will be put into operation, and the reconstruction work of 2 LNG-powered ships will be completed within three years. According to Lloyd's prediction, the LNG fuel will reach 11% of the market share maximally by 2030.

Due to China's complex inland navigation ship types and obsoleted ship equipment, different from European and American countries which are dominated by new-built ships, China mainly focuses on the reconstruction of fuel powered system with regard to the popularization of LNG-powered ship. Namely, without changing the original diesel engine structure, a flammable LNG hybrid combustion system is added without changing the original diesel oil engine structure to form a diesel oil –LNG hybrid system. Compared with the single fuel-powered system, the energy-saving and emission reduction of the dual fuel powered system mainly represent such aspects as reduction of noise pollution, reduction of dust and waste oily water discharge, reduction of sulfur oxides discharge up to 80%~90%, as well as carbon dioxide emission up to 15%~20%[®]. In April 2015, the first two inland river LNG dual fuel powered ships named "Shandong Zaozhuang Cargo Ship 2662" and "Shandong Zaozhuang Cargo Ship 3666" successfully launched for trial sailing in Zaozhuang City, which realized the

"0" breakthrough of inland river shipping clean energy source ship in Shandong Province.

Considering the safety hazard of the dual fuel powered ship, pure LNG-powered ships were put into operation in China's inland rivers in 2015, really realizing the fuel oil substitution rate of 100%. On March 5, 2015, China's first pure LNG-powered ship named "Green Power 6002" had a successful sailing trial, which adopted pure LNG fuel engine as main propulsion mainframe, reaching 25% reduction of the carbon dioxide emissions, 90% reduction of nitrogen oxide emissions and zero emission of sulfur oxides, PM2.5, oily water and domestic sewage, so it is regarded as a real clean ship[®]. Since March in this year, the first three pure LNG-powered ships have been constructed in Yancheng, Jiangsu Province. Once they are put into operation, the fuel costs will reduce by 30% at most, and LNG burning can reduce the nitrogen oxides emission up to 39% and carbon dioxide emission up to 90%. Since March 28, Shanghai Green Power Water Transport Co., Ltd. (hereinafter referred to as the "Green Water Transport") has begun to construct the first 200 LNG-powered ships, which emblemizes the commencement of a large-scale renewal of inland river water transportation tools.

7. CONCLUSION

In summary, four conclusions are deduced as follows, aiming at the cause analyses of the wide popularization and use of LNG-powered ship in the inland river of the Yangtze River:

1) The development and utilization of natural gas has changed the global energy source structure, reduced the dependence of ship fuels on petroleum, which becomes one of the motivations for the rapid development of LNG-powered ships at home and abroad.

2) In comparison with ordinary fuels, LNG, as ship driving fuel, reduces the burden on the environment during use; the higher performance price ratio of LNG meets the benefits of ship owners; the wide distribution of natural gas supply facilities and the establishment of large-scale LNG receiving stations meet the inherent requirements for the shipping economy, which lays solid foundations for the rapid development of LNG-powered ships in the inland rivers of China.

3) With the increase of emission control areas in recent years, much stricter rules for the emission of ship nitrogen oxides (NOx) and sulfur oxides (SOx) are prescribed in MARPOL convention, together with the formulation of relevant safety rules for LNG-powered ships (IGF rules), which accelerates the speed of transformation towards LNG driving fuel.



4) In accordance with the IGF rules for the safe use of gas-powered ships, China has formulated relevant polices for safety supervision and management on LNG ships, which provide legal bases for the safe use of these ships in the inland rivers of China and the Yangtze River.

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