【欧州】【海事】

Maritime Issues – Utilisation of LNG as fuel: Controversy on the benefits of using LNG for reducing GHG emissions in maritime transport

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【概要：Summary】

Liquefied natural gas (LNG) utilisation is growing in maritime transport, as it has a lower level of SOx, NOx and PM emissions than other fossil oil-based marine fuel. LNG is in particular an alternative for complying with the new global sulphur limit of 0.5%, which will be applied as of 1 January 2020. However, the utilisation of LNG in maritime transport also requires large-scale investments for bunkering infrastructure facilities, while LNG still needs to be evaluated as a sustainable alternative to other marine fuels. Regarding decarbonisation of maritime transport, some studies underline that due to the methane leakage in the LNG production, storage, transport and bunkering as well as engine operation, LNG is not the best choice as a sustainable fuel. The methane slip could eliminate all advantages of GHG emission reduction the utilisation of LNG would potentially have. In fact, some studies have investigated the advantages of LNG regarding GHG emission reduction compared to other marine fuels and the environmental advantage of LNG in maritime transport is not entirely clarified. The list of studies presented in this article is not exhaustive. However, most research results emphasise the problem of methane slip in the utilisation of LNG as methane is a GHG, 20 times more potent than CO2. Most studies come to the conclusion that the alleged advantages of using LNG could be only marginal or not existent at all, if the methane slip cannot be eliminated.

Consequently, also an UMAS study of 2018 underlines that the advantages of LNG as marine fuel are limited and that Europe should better support other technologies that deliver much greater GHG emissions reductions. LNG could not be a bridge fuel, but an expensive deviation that ties up financial resources and funding, which could be better used for the development and deployment of other propulsion alternatives for decarbonisation in the maritime transport sector.

However, meanwhile, the consultancy thinkstep presented a study emphasising the advantages in using LNG in maritime transport. According to this study, LNG could help to achieve a decarbonisation of the maritime transport. The thinkstep study on the life cycle of GHG emissions on the use of LNG as marine fuel showed that on an engine technology basis, the absolute Well-to-Wake GHG emissions reductions for gas fuelled engines compared with HFO are from 14% to 21% for 2-stroke slow speed engines, and from 7% to 15% for 4-stroke medium speed engines. However, these results are challenged and questioned by other researchers. The controversies focus on the fact that actually there is only one type of engine and LNG combination that show the advantages of LNG for reducing GHG emissions in maritime transport. The criticism with the thinkstep report underlines the importance of controlling and regulating methane slip

to ensure that LNG can deliver GHG emission reductions in maritime transport.

【記事：Article】

1. Introduction of regulations on emission reduction in maritime transport

In order to achieve the Paris Agreement target of limiting the temperature increase to below 2°C compared to pre-industrial levels, all sectors need to contribute their fair share to the overall global GHG emission reduction efforts. Maritime transport is not included in the Paris Agreement, but the International Maritime Organisation (IMO) has taken the decision to reduce the GHG emissions of maritime transport. On 13 On 13 April 2018, the IMO's Marine Environment Protection Committee (MEPC) 72 adopted the initial strategy on GHG emission reduction for international shipping and related guiding principles. The strategy is the first step in a three-step approach towards achieving a reduction of GHG emissions in maritime transport. The total shipping sector's GHG emissions should be reduced by "at least" 50% by 2050, from 2008 levels. However, the initial strategy does not give a timetable for rolling out legal restrictions on CO2 output. In October 2018, the IMO's MEPC's 73th session moved ahead with its work to deliver the IMO initial strategy on the reduction of GHG emissions from ships, approving a programme of follow-up actions. The MEPC 74 session in May 2019 approved, for adoption at the next session in April 2020, amendments to MARPOL Annex VI to significantly strengthen the Energy Efficiency Design Index (EEDI) "phase 3" requirements and agreed on the terms of reference for the Fourth IMO GHG Study, among others. The IMO's strategy is due to be revised by 2023, but no concrete measures on how to achieve it have been decided, yet.

Another relevant measure to reduce atmospheric pollution in maritime transport is the introduction of the new 0.5% sulphur limit outside the Sulphur Emission Control Areas (SECAs) or ECAs as of 1 January 2020. These regulations and rules on emission reduction in maritime transport lead to the necessity for the shipping industry to reconsider their future fuel choice for their vessels.

2. Utilisation of LNG in maritime transport

Based on the introduction of new regulations on emission reduction, the international shipping industry is under pressure to reduce GHG emissions as well as local pollutants, like SOX, NOX, and PM. In 2018, the most common marine fuels were Heavy Fuel Oil (HFO) and Marine Gas Oil (MGO), with a maximum sulphur limit of 3.5 wt.% outside ECAs, respectively 0.1 wt.% inside the ECAs. However, as a result of the new regulations the marine fuel SOx limits will change and the industry considers the utilisation of alternative fuels. The most commonly considered alternative fuels are Liquefied Natural Gas (LNG), Electricity, Biodiesel, and Methanol. Also Synthetic Fuels and Hydrogen for use in fuel cells could play a role. The type of alternative fuel selected and the proportion of conventional fuel substituted will have a direct impact on a vessel's emissions of GHG, NOx, and SOx. In maritime transport, LNG is considered being a less-polluting alternative fuel because it has benefits regarding the reduction of sulphur, NOx and PM emissions. LNG is particularly suited for long-distance transport and is important for the shipping industry when considering the options to comply with the new global sulphur limit in 2020. Using LNG as a marine fuel could reduce SOx to almost zero, while NOx emissions decline 95% and PM by up to 99%, compared to conventional marine fuels.

However, in recent years, some studies have also pointed out the problem of methane slip when using LNG, which could diminish the previously anticipated LNG benefits regarding the reduction of GHG emissions.

Nevertheless, LNG is already the fastest-growing segment of the marine fuels industry. Classification society DNV GL estimates a total of 159 LNG fuelled vessels are currently in operation, with another 145 on order. S&P Global Platts Analytics forecasts LNG could have an about 7% share of global bunker demand by 2030, up from around 3% this year.

3. The role of LNG regarding the GHG emissions reduction in maritime transport

3.1. The utilisation of LNG and the problem of methane slip

The utilisation of LNG is considered being a solution suitable for the vessels' fuel switch for meeting the upcoming regulations of the new global SOx limit and other pollutants. However, some studies point out that the benefits of LNG are limited regarding a reduction of GHG emissions. In particular two studies have already questioned the benefits of using LNG for reducing GHG emissions in maritime transport. The T&E commissioned study of Ricardo Energy & Environment concluded that natural gas could have advantages for the shipping sector, as it produces less SOx, NOx and PMs emissions. However, the LNG powered vessels' benefits regarding the GHG emissions are highly dependent on controlling and eliminating the methane slip. Methane emissions result from methane leakage during LNG production, storage, transportation and bunkering and through unburned methane emissions released during vessel operation via fuel combustion in the engine.

The U.S. Maritime Administration (MARAD) in partnership with the University of Delaware and the Rochester Institute of Technology released a study in 2015, entitled "Methane Emissions from Natural Gas Bunkering Operations in the Marine Sector: A Total Fuel Cycle Approach". According to this study, the methane slip can undermine -- and in some cases even negate — the overall GHG emission benefit of LNG compared to oil-based fuels. The MARAD study's key finding is that methane slip is a very important factor that can determine whether LNG systems will lead to GHG emissions reduction or increases compared to marine fuels. The study concludes that in the case of compression ignited LNG systems, methane slip is well controlled, and this research shows clear GHG emissions advantages compared to conventional fuel, even when routine bunkering leakage assumptions are loosened. However, in the case of spark ignited LNG systems, methane slip is significant, and can actually negate the advantages of the LNG system. The second important finding is that routine bunkering leakages can have a disproportionate impact on overall GHG emissions due to the high volume of natural gas throughput and the high global warming potential of methane. Therefore, the study concluded that natural gas is an expensive dead-end on the pathway to decarbonizing transport for almost all transport modes. However, the report for MARAD also stated that it was possible to reduce methane leakages during bunkering and that LNG had the potential to reducing the local air pollution.

In June 2018, the maritime consultancy University Maritime Advisory Services (UMAS), a sectoral advisory service partnership between the University College London (UCL) Energy Institute and MATRANS Ltd., published a report entitled "LNG as a marine fuel in the EU. Market, bunkering infrastructure investments and risks in the context of GHG reductions". The UMAS report focuses on the impacts of utilisation of LNG as marine fuel in the EU. Also this UMAS study revealed that switching to LNG would only have little positive effects on the decarbonisation in maritime transport. The UMAS report states that depending on the fuel's supply chain and use, a switch to LNG can even increase GHG emissions relative to conventional fuels in a Business as Usual scenario. This result is consistent with many other studies, particularly when including upstream methane emissions of LNG utilisation and all sources of GHG emissions regarding the production, storage, transportation and bunkering of LNG as well as unburned methane emissions released during vessel operation. Therefore, the UMAS report comes to the conclusion that LNG is not a bridge fuel, but an expensive deviation that would make it harder for the EU to achieve its shipping climate goals. Investing heavily into LNG-refuelling capacity for maritime and inland shipping would only yield GHG emission reductions ranging from 6% to 10%. The UMAS report suggests, Europe should better back other technologies that would deliver the much greater GHG emissions reductions, including portside charging or liquid hydrogen infrastructure.

The T&E report on the "Impacts on GHG emissions of deploying fossil gas in the transport sector" of October 2018 compiles the latest evidence on the environmental impacts of using gas as a transport fuel. It builds on a previous report by AEA-Ricardo but analyses in more detail the role of renewable methane or the impact of tax policy. According to this latest T&E report, fossil gas used in transport has no meaningful climate benefits, in particular when including the impact of methane slip. In its study entitled "Roadmap to Decarbonising European Shipping" of 15 November 2018, the T&E states that if the shipping industry is to take the Paris Agreement's targets seriously, zero emission shipping has to be achieved by 2050 and all newly built ships should be zero emission from approximately 2030 onwards. T&E even concludes that in order to meet the recent IMO goals of -50% shipping emissions by 2050 the maximum achievable 20% GHG reduction by LNG is not sufficient. Therefore, if the ship owners opted for LNG powered vessels in the first place, their fleet would have to be retrofitted again with zero emission fuels/propulsion technologies in order to meet the 2050 target. Accordingly, the existing vessel fleet should be retrofitted with zero GHG emission fuels/propulsion technologies and not LNG propulsion systems.

Furthermore, in July 2019, the UK's Department for Transport published its "Clean Maritime Plan", forming the Environment Route Map of the UK's Maritime 2050 strategy, including recommendations for developing the UK's maritime sector. To achieve the UK's transition to a future of zero emission shipping, the Clean Maritime Plan includes policies to tackle GHG emissions and air pollutants from shipping. Referring to the UMAS study, the UK Department for Transport's plan also emphasises that "LNG is not estimated to be a substantial part of the fuel mix in the future". Better alternatives to LNG have been developed or are emerging, like in shipping with electric or fuel cell propulsion systems. Therefore, the recent studies conclude that LNG could prove to be an expensive deviation on the way to decarbonising maritime transport. It could absorb important investment and funding, which actually is needed for developing the real alternative fuels to decarbonise the transport sector. The T&E and the MARAD study conclude that increased use of natural gas is largely ineffective in reducing GHG emissions due to the methane slip during production, bunkering and at the engine. While there exist some benefits of LNG in the reduction of SOx, NOx and PM, the alleged advantage of LNG regarding a reduction of GHG emissions can be only marginal compared to conventional marine fuels, if no measures are taken to reduce the methane slip.

3.2. New thinkstep study points out the life cycle GHG emission advantages of LNG compared to oil-based fuels

A recent study conducted by consultancy thinkstep and commissioned by SEA/LNG and SGMF entitled "Life Cycle GHG Emission Study on the Use of LNG as Marine Fuel" showed that, depending on the engine technology basis, LNG has some benefits regarding the absolute Well-to-Wake GHG emissions. The thinkstep study, which has been reviewed by a panel of independent academic experts, is considered being the most accurate study of the life cycle GHG emissions and local pollutants from LNG as a marine fuel on a complete WtW basis. The assessment of the carbon intensity of LNG is based on the full life cycle, including production and processing; pipeline transport; liquefaction; LNG carrier transportation (for imports); LNG terminal operations (for imports); bunkering (dispensing); and the final combustion in the engine. The report analysed several LNG pathways, including LNG from Algeria, Australia, Qatar, Indonesia, Malaysia, Nigeria, Norway, Trinidad & Tobago and the USA. The study used the latest primary data to assess all major types of marine engines provided by Original Equipment Manufacturers including Caterpillar MaK, Caterpillar Solar Turbines, GE, MAN Energy Solutions, Rolls Royce (MTU), Wärtsilä, and Winterthur Gas & Diesel, as well as from ExxonMobil, Shell, and Total from the suppliers' side. According to the study, the use of LNG leads to a reduction of GHG emissions in the Well-to-Wake (WtW) emissions for gas-fuelled engines compared to heavy-fuel oil (HFO) fuelled engines of between 14% to 21% for 2-stroke slow speed engines, and between 7% to 15% for 4-stroke medium speed engines over the entire life-cycle. 72% of currently utilised marine fuel is consumed by 2-stroke engines and 18% is used by 4-stroke medium speed engines, according to the study. This new "Well-to-Wake" study therefore considers LNG as major contributor in meeting IMO's 2050 GHG targets for shipping. The study also concludes that the widely discussed methane slip or "Total Hydrocarbon (THC) Emissions" is a problem related to the applied heat cycle, and that the amount of methane slip depends on the technology of each engine. The study also showed that using LNG as a marine fuel reduces SOx to almost zero, while NOx emissions decline 95% and particulates by up to 99% compared with conventional HFO (Heavy-Fuel Oil) fuels.

On-going optimisation in supply chain and engine technology developments could further increase the benefits of LNG as a marine fuel. Furthermore, bioLNG and Synthetic LNG, which can both substitute LNG derived from fossil feedstock, offer the potential for significant additional GHG emissions reductions.

The study concludes that over the entire life cycle from Well-to-Wake (WtW), the GHG reductions of up to 21% are achievable now from LNG compared with current oil-based marine fuels and depending on the engine technology basis.

Considering the benefit of LNG compared with HFO fuelled engines on a Tank-to-Wake (TtW) basis, the combustion process for LNG shows GHG benefits of up to 28% compared with current oil-based marine fuels. The TtW emissions reduction benefits for LNG fuelled engines compared with HFO fuelled engines are from 18% to 28% for 2-stroke slow speed engines and from 12% to 22% for 4-stroke medium speed engines. The study revealed that the methane slip remains a significant problem in low-pressure engines, ranging from 10% to 17%.

3.3. Controversy over LNG study results

The thinkstep study's results regarding the LNG benefits have been met with criticism. While the thinkstep study claims GHG savings of up to 21% on a WtW basis if ships use LNG compared to alternative fossil fuels, Norwegian research institute SINTEF Ocean's chief scientist Dr Elizabeth Lindstad commented critically several issues with the methodology of the thinkstep analysis. The NGO Transport & Environment (T&E) decided to publish Lindstad's commentary in order to raise public and industry awareness of the dangers of a large-scale shift to LNG in the maritime sector. Lindstad pointed out three faulty assumptions in the thinkstep study. These include the well-to-wake emissions for heavy fuel oil (HFO), which are calculated too high, given modern refining efficiency; unaccountable differences in the thermal efficiencies of engines burning HFO and LNG; and unburned methane figures taken from an engine load range that does not reflect the reality of contemporary ship operations. According to Lindstad, the results from her own calculations indicate that the only LNG option, which contributes to reducing GHG emissions, is the two—stroke, high-pressure engine. For all other options, GHG emissions increase or are equal to using MGO or HFO. Consequently, Lindstad challenges the GHG emission reductions by using LNG as a marine fuel.

Methane slip represents inefficiency, so engine manufacturers are strongly incentivised to reduce it. As regulations emerge, technical solutions to the methane slip problem are urgently needed. Most four-stroke engines burning LNG use low-pressure gas, which leads to more unburned methane than high-pressure injection technologies. As potential solutions it is discussed to create four-stroke engines using high-pressure injection instead. In theory, using emission and energy coefficients in combustion only, LNG results in about 25% lower GHG emissions than diesel (MGO) or bunker oil(HFO). However, larger well to tank (WTT) emissions for the LNG supply chain as well as un-combusted methane (CH4) from the ship's engine might more than nullify any GHG gains. A key question to ask would be, according to Lindstad, when such a large reduction figures are presented, how the study got to these results. The results from Lindstad's own calculations indicate that the only LNG option, which contributes to reducing GHG emissions, is the 2-stroke high-pressure dual fuel option (HP-DF-LNG). For all other LNG options, the GHG emissions increase or are equal to using MGO or HFO. This stands in contrast to the thinkstep results, which indicate a reduction potential for all LNG options to a lower or higher extent.

In addition, as a carbon-based fuel of fossil origin, the combustion of LNG will still result in CO2 emissions rather than eliminating them during shipping. Considering that the residence time of CO2 in the atmosphere is thousands of years, and that there is a carbon budget implied in the goals of the Paris Agreement, even with the high pressure dual fuel option (HP-DF-LNG), maritime transport risks to be locked into a high-carbon infrastructure in the long term, when using LNG, rather than opting for new technologies that could lead to zero GHG emissions, like Synthetic Fuels, or Hydrogen for use in fuel cells.

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