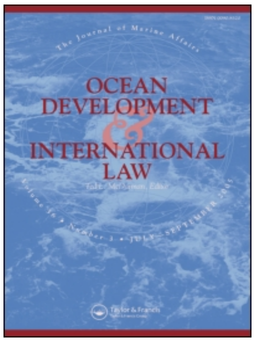

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Jingjing Xu, David Testa & Proshanto K. Mukherjee

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The Use of LNG as a Marine Fuel: The International Regulatory Framework

JINGJING XU
DAVID TESTA

Plymouth Graduate School of Management
Faculty of Business
Plymouth University
Plymouth, United Kingdom

PROSHANTO K. MUKHERJEE

School of Law
Dalian Maritime University
Dalian, China

While shipping is a carbon efficient transport mode, given that roughly 90% of the world trade is carried by ships, the negative impact of shipping on human health and the natural environment is significant. One of the attempts being made by the shipping industry to reduce its environmental impact is to use liquefied natural gas (LNG) as a marine fuel. This article examines the regulatory legal regime in relation to the use of LNG as marine fuel and highlights the areas where further development is necessary.

Keywords IMO, LNG, marine fuel

Introduction

Shipping has been widely recognized as the backbone of international trade, and it is currently the most carbon efficient mode of international transport. It has been estimated that shipping is responsible for approximately 3% of global carbon dioxide emissions.[1] While there is a strong downward trend in land-based sulfur oxide emissions, that is not happening with ship-source emissions of sulfur oxide.[2] There is a growing concern over climate change and air pollution in all sectors and, for international shipping, there is significant pressure to reduce exhaust emissions being placed on an industry that is well known for its conservative ways.

Various incentives and motivations, including laws and regulations, to reduce shipping's exhaust emissions are being adopted. One of the emission reduction attempts

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Address correspondence to Professor Jingjing Xu, Faculty of Business, Cookworthy Building, Plymouth University, Drake Circus, Plymouth, PL4 8AA United Kingdom. E-mail: jingjing.xu@plymouth.ac.uk

is the use of LNG as a marine fuel. LNG, as a marine fuel, produces virtually 0% sulfur dioxide emissions. Moreover, compared with conventional marine bunker fuels, LNG has the potential to reduce carbon dioxide emissions by 10% to 20%, nitrogen oxide emissions by up to 80% or 90%, and particulate matter emission by 98% to 100%.[3]

A study commissioned by Lloyd's Register in April 2011 about LNG-fueled deep sea shipping confirmed that, owing to its competitive market price, it is likely that LNG will be widely adopted as a marine fuel in the future.[4] Through a survey of shipowners, the study revealed that legislation regulating ship-source emissions plays an important role in encouraging the use of LNG as a marine fuel. The study also showed that, to achieve compliance with sulfur emission regulations, low-sulfur fuels are considered by shipowners only as only a short-term solution whereas using LNG-fueled engines is seen as being a viable long-term solution for ships engaged in liner shipping (i.e., container vessels).[5] The significant role that LNG may play in the future is confirmed in the recent report by Det Norske Veritas (DNV) "Shipping 2020," which suggested that by 2018−2020 about 30% of new ships will be delivered with gas engines, with larger ships being set to benefit the most from running on gas "due to economies of scale in installation and the sheer amount of fuel used by these ships."[6] In August 2014, the world's first dual-fuel slow-speed engine was installed into the world's first LNG-powered container ship. The state-of-the-art ME-GI engine represents the next generation of technology that is poised to lead shipping into an era of being a cleaner and safer industry as realization of the merits of LNG marine fuel grows.[7]

Coinciding with the predictions made in the above studies, the current state of development in the industry indicates that using LNG as a marine fuel has become increasingly common. For some types of ships, this alternative fuel has become a strong competitor to traditional bunker fuels and, for those ship types that were not traditionally associated with LNG, the utilization of LNG as a marine fuel has started to emerge. In early 2013, for instance, Viking Line, a ferry company based in Finland, took delivery of the M/S *Viking Grace*. Costing approximately €240 million, the ship is presently the world's largest LNG-fueled passenger vessel.[8]

The increasing number of ships opting to utilize LNG as their choice of marine fuel is in sharp contrast with the state of development of the international legal framework governing the use of LNG as a marine fuel. This article examines in detail the international regulatory issues in relation to the use of LNG as a marine fuel and highlights the areas where further developments are necessary.

To provide an analytical background for the discussion in this article, a brief overview of the international and regional regulations governing ship-source exhaust emissions is first presented. These regulations establish tight controls over ship emissions and give an incentive to shipowners to seek the best and possibly the cheapest means, such as LNG, to comply with the requirements in both the short and long term. Attention is focused on the International Convention for the Prevention of Pollution from Ships (MARPOL),[9] the main international convention of relevance, and European Union (EU) legislation and the Union's approach to reducing shipping emissions by using LNG as a marine fuel.[10]

The International Legal Regimes Governing Ship-Source Exhaust Emissions

The MARPOL Convention

The MARPOL Convention addressed five types of pollutants through its five original Annexes: Oil, Noxious Liquid Substances, Packaged Harmful Substances, Sewage, and

Garbage. In 1997 through a protocol that entered into force in 2005, Annex VI was added to deal with the problem of air pollution caused by exhaust emissions from ships.[11] Annex VI establishes limits on sulfur oxide and nitrogen oxide emissions from ship exhausts, prohibits deliberate emissions of ozone-depleting substances, and provides for emission control areas in which more stringent standards apply.[12]

In 2008 amendments to Annex VI were made, and they became legally effective from 2012.[13] One of the amendments reduces the global sulfur cap to 3.50% with a potential further decrease to 0.50% in January 2020, subject to a feasibility review to be completed no later than 2018.[14] Stricter limits were also introduced for sulfur oxide emission control areas (SECAs),[15] where a limit of 1.00% became applicable from 1 July 2010 and a 0.10% limit to apply from 1 January 2015. The situation with regard to controls on sulfur content in marine fuels under Regulation 14 of Annex VI is set out in Table 1. The 4.5% cap on sulfur content was considered groundbreaking when adopted,[16] and the move to 3.50% as a general limit is significant. The potential move to a 0.50% limit in 2020 constitutes a major incentive for the widescale adoption of LNG as a marine fuel. With these relatively new requirements, shipowners are faced with the question of how best to make their vessels compliant with Annex VI in both the short and the long term.[17]

Another important set of amendments was adopted in 2011, with a new Chapter 4 entitled "Regulations on Energy Efficiency for Ships" added to Annex VI.[18] The new chapter introduced mandatory measures to reduce greenhouse gas emissions from international shipping,[19] and is the first compulsory greenhouse gas reduction regime adopted in relation to ships applicable across the entire international shipping sector.[20] The amendments also represent the first serious attempt within the International Maritime Organization (IMO) to regulate greenhouse gas emissions from ships, a task that was specifically assigned to the IMO through the Kyoto Protocol.[21]

Chapter 4 introduces two important mechanisms: the Energy Efficiency Design Index (EEDI) and the Ship Energy Efficiency Management Plan (SEEMP). The EEDI[22] applies to all ships of 400 gross tons and above (although waivers may be granted) and requires that new ships be designed in a more energy efficient manner to emit less greenhouse gases. Several technical methods are available for shipowners seeking to increase the energy efficiency of their ships. Since LNG can be classified as a low-carbon fuel that has the potential to reduce carbon dioxide emissions by around 20%, utilizing LNG as a marine fuel is one of the options by which compliance with the EEDI requirements can be achieved.

With regard to the SEEMP, Chapter 4 provides little detail. Regulation 22 of Chapter 4 indicates that each ship is to carry on board a ship-specific SEEMP and that this is to be developed by taking into account the relevant SEEMP Guidelines adopted by the IMO.[23] The SEEMP Guidelines explain that a SEEMP should improve a ship's energy efficiency through four steps: planning, implementation, monitoring, and self-evaluation and improvement.

Planning is described as the most crucial stage and is intended, on the one hand, to ascertain the status of ship energy usage and, on the other, to establish the expected improvement of ship energy efficiency. Procedures adopted by companies vis-à-vis their respective ships are to be developed "in a manner which limits any onboard administrative burden to the minimum necessary."[24] Insofar as implementation is concerned, the SEEMP is expected to prescribe how each proposed measure is to be implemented and to assign responsibilities to specific persons. Monitoring is required to enable self-evaluation and improvement and, while considerable leeway is allocated to vessel operators, monitoring is to be carried out by an established method preferably constitutive of an

Table 1
Summary of sulfur content in Regulation 14 to Annex VI

Maximum permissible amount of sulfur content of fuel oil used on board ships in areas outside Emission Control Areas	4.50% m/m prior to 1 January 2012	3.50% m/m on and after 1 January 2012	0.50% m/m on and after 1 January 2020[a]
Maximum permissible amount of sulfur content of fuel oil used on board ships within Emission Control Areas	1.50% m/m prior to 1 July 2010	1.00% m/m on and after 1 July 2010	0.10% m/m on and after 1 January 2015

[a]This reduction is subject to a feasibility review that is to be completed no later than 2018. Depending on fuel supply, the limit of 0.50% may be introduced by the year 2025 at the latest.

international standard. Finally, self-evaluation and improvement is intended to provide meaningful feedback to be utilized for the planning stage of the next improvement cycle.

The SEEMP Guidelines also recognize that "emerging alternative fuels may be considered as a CO_2 reduction method," and that "availability will often determine the applicability."[25] Notably, the potential afforded by LNG in terms of carbon dioxide emissions reduction in the shipping industry is roughly 20%; thus, to achieve a satisfactory decrease in such emissions, other measures may also required.

EU Measures

The EU has shown a commitment to aligning its policies with those adopted by the IMO, not only for the control of ship emissions in general but also in the use of LNG as a marine fuel in particular. In some cases, the EU has adopted measures that go beyond what the IMO has established, leaving the door open for these measures to be integrated within future IMO initiatives.[26]

The most relevant EU measure is Council Directive 1999/32/EC, which regulates the sulfur content of marine fuels. The directive has been amended a number of times, the most recent being through Directive 2012/33/EU[27] which has a twofold aim of making the EU's rules on sulfur content of marine fuels compliant with international law and of ensuring that the new global sulfur standards can be enforced throughout the EU. For this reason, to a large extent, the amended Council Directive 1999/32/EC mirrors the amended Annex VI of MARPOL, although in certain aspects the directive is stricter and more elaborate.

The limits on the sulfur content of marine fuels provided in the amended Article 4(a) of Directive 2012/33/EU are:

- Member States must ensure that marine fuels are not used in their territorial seas, exclusive economic zones (EEZs) and pollution control zones falling within SO_x Emission Control Areas if the sulphur content of those fuels by mass exceeds: (a) 1.00% until 31 December 2014; (b) 0.10% as from 1 January 2015.
- Member States must ensure that marine fuels are not used in their territorial seas, EEZs and pollution control zones if the sulphur content of those fuels by mass exceeds: (a) 3.50% as from 18 June 2014; (b) 0.50% as from 1 January 2020.
- Member States must ensure that marine fuels are not used in their territorial seas, EEZs and pollution control zones falling outside SO_x Emission Control Areas by passenger ships operating on regular services to or from any Union port if the sulphur content of those fuels exceeds 1.50% by mass until 1 January 2020 (when the 0.50% limit will apply).

While the first two points replicate the limits in MARPOL Annex VI, the provision regarding passenger ships is unique to the EU. A stricter limit is provided since passenger ships tend to operate in ports and close to coastal areas with their impact on human health and the environment likely to be more significant.[28]

In establishing measures for reducing greenhouse gas emissions from ships, the willingness of the EU to go beyond what the IMO has established is more pronounced. It shows what can perhaps be described as justifiable impatience with the pace of developments at the international level. In June 2013, the European

Commission adopted a strategy for progressively integrating the maritime sector into the EU's policy for reducing greenhouse gas emissions.[29] The strategy is based on a stage-by-stage approach consisting of three consecutive steps: (1) the implementation of a monitoring, reporting, and verification (MRV) system for carbon dioxide emissions; (2) the setting of greenhouse gas reduction targets for the maritime transport sector; and (3) the implementation of additional measures to encourage reductions in emissions such as market-based measures.

It is evident from various EU documents that supporting the use of LNG as a marine fuel is high on the Union's agenda. The EU has effectively categorized LNG as the most promising alternative fuel for ships.[30] It has been estimated that approximately 10,000 ships are employed in European short-sea shipping, about 5,000 of which spend more than 50% of their time in SECAs. LNG as a fuel constitutes an attractive option to this category of ships, considering that starting from 2015 they will be bound by the requirement to utilize marine fuels with a content of no more than 0.1% sulfur.[31] The EU hopes that the price of LNG fuel will also become more attractive and that this will encourage the use of LNG fuel even by those vessels that operate beyond Emission Control Areas.[32]

It is worth noting that the EU has numerous instruments that deal with LNG as a marine fuel for inland vessels such as the Rhine Vessel Inspection Regulations (RVIR),[33] Directive 2006/87/EG,[34] and the European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN).[35] Moreover, the Central Commission for the Navigation of the Rhine (CCNR) has committed to supporting the development of LNG use as a marine fuel in inland waterways. A first step was taken in October 2013 when, together with a number of partners, the CCNR announced the launch of an Internet database to serve as a platform for the vast array of LNG projects relating to European inland navigation that are completed, ongoing, or planned.[36] The CCNR recognizes that the introduction of LNG as a marine fuel in inland waterways requires simultaneous action at several levels, including: the development of regulations, infrastructure establishment, and the building of new ships.

A working document issued by the European Commission recognizes the importance of attaining compatibility in the rules being developed for the use of LNG in international shipping and inland waterways, respectively. This would serve to "improve interfaces for sea/river going vessels and economies of scale for LNG provision in ports with sea and inland waterway access."[37]

The Codes and Guidelines Applicable to the Use of LNG as a Marine Fuel

IMO Instruments

Until recently, the use of LNG as fuel was mostly confined to LNG tankers that utilized the vapor or boil-off gas from their cargo as a source of fuel. The only international instrument relevant to the use of gas as a marine fuel was the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code).[38] The code was adopted in 1983 and made mandatory through the International Convention for the Safety of Life at Sea (SOLAS)[39] with regard to all new gas carriers built after 1986. The IGC Code was designed to be an international standard for the safe transport of liquefied gases in bulk and certain other substances at sea. The IGC Code prescribes the standards for the design and construction of ships involved in such transport and determines the equipment that needs to be carried to minimize the risk to the ship, its crew, and the environment. Chapter 16 deals with the use of cargo as fuel, where the thermal oxidation method (i.e., the system where the boil-off vapors are utilized as fuel for shipboard use or as a waste heat system) is covered. The relevance of the IGC Code to the broader use of LNG as a marine fuel is limited.

As the use of LNG as an alternative to conventional fuels became recognized, so did the need for a specific code. In 2004, Norway proposed the development of an International Code for Gas-Fuelled Ships.[40] The first step was the adoption in 2009 of the Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships.[41] The goal of the Natural Gas-Fuelled Ships Interim Guidelines is

> . . . to provide criteria for the arrangement and installation of machinery for propulsion and auxiliary purposes, using natural gas as fuel, which will have an equivalent level of integrity in terms of safety, reliability and dependability as that which can be achieved with a new and comparable conventional oil-fuelled main and auxiliary machinery.[42]

As set out in Section 1.1.3, the guidelines apply to new ships with the application to existing ships left to be determined by the individual states.

The functional requirements are set out under the guidelines' seven headings: Ship Arrangements and System Design; Fire Safety; Electrical Systems; Control, Monitoring and Safety Systems; Compressors and Gas Engines; Manufacture, Workmanship and Testing; Operational and Training Requirements.

In Chapter 2 of the Natural Gas-Fuelled Ships Interim Guidelines it is set out that, following any new or altered concept or configuration, a risk analysis is to be conducted so as to address any safety deficiencies arising from the use of gas-fueled engines that affect the structural strength and integrity of the ship. The guidelines aim to ascertain that such risk analysis be carried out in terms of "acceptable and recognized risk analysis techniques."

The guidelines contain a noteworthy mix of standards, references to provisions of the IGC Code and other relevant international instruments as well as references to international standards.[43]

The International Code for Ships Using Gas or Other Low Flash-Point Fuels (IGF Code) is under consideration within the IMO.[44] It is intended to be a legally binding instrument that will set uniform standards and avoid the risk of differing, and potentially inadequate, national legislation being adopted. The Preamble to the draft IGF Code states that:

> . . . the basic philosophy of the Code is to provide mandatory criteria for the arrangement and installation of machinery, equipment and systems for vessels operating with gas or low-flashpoint liquids as fuel to minimize the risk to the ship, its crew and the environment.

The Preamble recognizes that, given the pace at which developments are taking place in this area, the code will need to be periodically reviewed so as to take into account both the experience of using LNG as a marine fuel and new technological developments.

The draft IGF Code has four parts: Part A: Design; Part B: Alternative Design; Part C: Manufacturing; and Part D: Operation. While the primary focus of the code is the use of natural gas as fuel, it also addresses several other low-flash-point fuels. In Part A, Section A-1 sets out specific design requirements for ships using natural gas as fuel, and

Sections A-2 to A-7 lay down design requirements for other low-flash-point fuels, including propane, butane, ethyl or methyl alcohol, hydrogen, and dimethyl ether.

Part B of the draft IGF Code allows appliances and arrangements to deviate from the strict requirements set out in Section A as long as the alternative design and arrangements meet the intent of the requirements concerned and provide an equivalent level of safety. When alternative arrangements are adopted, Section 16.1.2 requires that an engineering analysis, evaluation, and approval of the arrangements be carried out. The analysis must also be approved by the state administration and, if any assumptions and operational restrictions stipulated in the alternative design and arrangements are changed, another engineering analysis must be conducted.

Part C is concerned with manufacturing, with Section 17.1.1 indicating that "the manufacture, testing, inspection and documentation [must] be in accordance with recognized standards and the specific requirements given in the [IGF] Code."[45] Detailed requirements are provided on testing related to gas tanks[46] and gas-piping systems.

Part D deals with training and operational requirements. The central provision is Section 18.3.1, which provides:

> The whole operational crew of a cargo or a passenger ship using fuel addressed by this code shall have necessary training in gas-related safety, operation and maintenance prior to the commencement of work on board. Additionally, crew members with a direct responsibility for the operation of fuel-related equipment on board shall receive special training.

The shipowning company is required to document that its personnel have acquired, and maintain at all times, the knowledge necessary to ensure safe operation according to the standards established in the code. With respect to training, it was agreed that the appropriate instruments for the establishment of the training and certification for personnel on ships using gases were Chapter V of the International Convention on Standards of Training, Certification and Watchkeeping for Seafarers (STCW Convention)[47] and the STCW Code.[48]

While the central issues related to the use of LNG as a marine fuel are adequately dealt with by the draft IGF Code, there are some areas which await future attention.[49] Foremost among these is the process of bunkering LNG. The absence of sufficiently comprehensive regulations here is particularly unfortunate considering that, at present, the inadequacy of bunkering infrastructure constitutes a major barrier to increased adoption of LNG as a marine fuel.[50] The problem has often been described as a chicken-and-egg situation. So long as the necessary bunkering infrastructure is lacking, the shipping industry will not be willing to invest in LNG-fueled ships. On the other hand, if a sufficient demand for LNG fuel from the shipping industry is not perceived or forthcoming, bunker suppliers will be unwilling to make the necessary infrastructural investments. Incentives appear to be required to overcome this. A study undertaken by *Lloyd's Register*, which surveyed 25 deep sea bunkering ports on the likelihood of developing LNG bunkering infrastructure, indicated that one of the key drivers for a change to LNG was to the adoption of regulations.[51] This said, only a small number (8%) of the responding ports were found to have regulations in place for LNG bunkering.[52] This points to a need for regulations at the international level to lead the way.

A positive development is that, within the EU, it has recently been proposed to have LNG refueling stations installed in all maritime and inland ports of the trans-European (TEN-T) core network by 2020 (2025 for inland ports).[53]

To ensure that the use of LNG as a marine fuel is a safe alternative, uniformity in the regulations for the bunkering process is of importance. While the draft IGF Code deals with bunkering issues to some extent, the focus is mostly on the receiving of gas-fueled ships. Notably, comprehensive operational guidance on the interface between a bunker vessel and a receiving vessel is woefully inadequate. Further shortcomings of the draft IGF Code with regard to bunkering of LNG are highlighted in a study conducted by the European Maritime Safety Agency (EMSA).[54] This study notes that:

- Positively, Article 19.3.1 of the draft IGF Code defines the assignment of responsibility in the case of ship-to-ship (STS) bunkering.[55] On the other hand, no account is taken of bunkering processes other than the STS bunkering interface.
- While the draft IGF Code provides general definitions of gases and general conditions, a definition of the minimum requirements for gas quality is lacking.
- No provision is made to determine suitable procedures for the sampling of LNG bunker fuel.[56]

ISO Guidelines

Since the draft IGF Code is inadequate pertaining to the bunkering process, if the highest possible level of safety is to be attained, a more comprehensive set of regulations is needed that will take account of all aspects of the bunkering process including the ship–bunkering facility interface. Norway spearheaded an initiative within the International Organization for Standardization (ISO) that led to the development of the draft Guidelines for Systems and Installations for Supply of LNG as Fuel to Ships.[57] With the goal of ensuring that a ship can refuel with the highest possible level of safety regardless of the type of bunkering facility in question, the guidelines provide direction for the planning and design of: the bunkering facility, the ship–bunkering facility interface, procedures for connection and disconnection, the emergency shutdown interface, and the LNG bunkering process control. As provided in Article 1, the guidelines apply to the bunkering of seagoing and inland trading vessels alike. They cover LNG bunkering from both shore and ship LNG supply facilities and address the entire spectrum of operations involved in the supply of LNG, including inerting, gassing up, cooling down, and loading.

It is clear that the ISO Guidelines were developed to address the industry's need for "guidance for the equipment, systems, procedures and training for those parties engaged in the delivery of LNG as fuel to ships."[58] While the ISO Guidelines are more comprehensive than the draft IGF Code with respect to the bunkering process, a number of deficiencies are notable. The ISO Guidelines do not constitute an international standard, but rather are intended for provisional prestandardization application, with the intention being to gather experience of their use. Only after that is it envisaged that the guidelines may be further developed. While this is not ideal, the decision to not adopt the guidelines more formally can be understood since the solutions available are at a relatively early stage of development and deployment.

A number of deficiencies in the substantive content of the ISO Guidelines have been noted.[59] Nevertheless, the ISO Guidelines are a welcome development. It is hoped that, following a period of experience gathering, they will be improved on and play a crucial role in the establishing of an international standard in the area of LNG bunkering as a marine fuel.

Classification Society Rules

A number of classification societies have developed rules with respect to the use of LNG as a marine fuel that are based, to various extents, on the 2009 Natural Gas-Fuelled Ships Interim Guidelines and the draft IGF Code. The rules issued by the Det Norske Veritas (DNV) classification society in 2001, entitled Gas-Fuelled Engine Installations, are particularly noteworthy.[60] The 2009 Natural Gas-Fuelled Ships Interim Guidelines contain much of the substantive content of the DNV rules.[61]

A selection of some of the rules for gas-fueled ships adopted by classification societies are set out in Table 2. Across these rules are many common features. Those issued by Germanischer Lloyd AG, ClassNK, Bureau Veritas (BV), and DNV share the same content and reflect the chapter outline contained in the 2009 Natural Gas-Fuelled Ships Guidelines. The ones from the American Bureau of Shipping (ABS) are different than those outlined but cover, to a large extent, the same content.

Although there are many commonalities between the classification societies' rules and the Natural Gas-Fuelled Ships Guidelines, there are differences as well. For instance, regarding the general requirement for a fuel bunkering station, the Natural Gas-Fuelled Ships Interim Guidelines, Section 2.9.1.1, provides that:

> The bunkering station should be physically separated or structurally shielded from accommodation, cargo/working deck and control stations. Connections and piping should be so positioned and arranged that any damage to the gas piping does not cause damage to the vessel's gas storage tank arrangement leading to uncontrolled gas discharge.

This provision is reproduced (practically word for word) in Section 9.1.1 of Bureau Veritas rules which, however, goes on to provide that:

Table 2
Classification society guidelines

Classification society	Title of guideline
American Bureau of Shipping	Guide for Propulsion and Auxiliary Systems for Gas-Fuelled Ships[a]
Germanischer Lloyd AG	Guidelines for the Use of Gas as Fuel for Ships[b]
ClassNK	Guidelines for Gas-Fuelled Ships[c]
Bureau Veritas (BV)	Safety for Gas-Fuelled Engine Installations in Ships[d]
Det Norske Veritas (DNV)	Gas-Fuelled Engine Installations[e]

[a]Available at www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA%20Repository/Rules&Guides/Current/181_GasFueledShips/Guide.
[b]Available at www.gl-group.com/infoServices/rules/pdfs/gl_vi-3-1_e.pdf.
[c]See www.classnk.or.jp/hp/en/hp_news.aspx?id=715&type=press_release&layout=1.
[d]Available at www.veristar.com/content/static/veristarinfo/images/4707.9.529NR_2011-05.pdf.
[e]Available at exchange.dnv.com/publishing/ruleshslc/2011-01/ts613.pdf.

> . . . particular attention is to be paid to the hazardous areas created during bunkering operations and to the possible access restrictions in order to avoid the presence of unauthorized persons in the vicinity of these hazardous areas.[62]

Among the classification societies' rules, those of the ABS are the most comprehensive.[63] For example, with regard to bunkering, by taking cognizance of the ISO Guidelines, they go beyond the ambit of the draft IGF Code, by requiring that detailed instruction manuals be maintained on board covering operations, safety, maintenance requirements, and occupational health hazards relevant to the use of LNG as marine fuel.

The rules developed by the various classification societies for the use of LNG as marine fuel are fragmented. Without international legally binding obligations, each state makes its own decisions in regard to the operation of gas-fueled vessels with the classification society rules playing a useful role in the national regulatory process.[64]

Conclusion

While strict and clear regulations to control emissions from ships exist, ostensibly encouraging the use of alternative marine fuels including LNG, the international maritime community has not yet provided an adequate regulatory regime for the activity it encourages.

The draft IGF Code is a good initiative in that it introduces binding regulations on the use of LNG as a marine fuel. However, there are deficiencies that make the code less than comprehensive. A major deficiency is that it fails to provide regulations on the bunkering process. Considering the inherent risk of explosion in bunkering operations and the need to ensure that a high degree of safety is maintained, such a failure is significant.

The ISO Guidelines remedy this to a point and are a welcome development, but further improvements could be made including:

- provision of a better definition of the division of responsibility with regard to the bunkering process between ship operator and those responsible for bunkering infrastructure;
- provision of better regulation of the simultaneous bunkering of LNG with passenger embarkation and disembarkation;
- and the introduction of a requirement to provide details of the transferred LNG fuel's sulfur content as part of the supplier's obligation to provide documentation of the quality of LNG fuel transferred.

The need to convert the ISO Guidelines, subject to amendments and improvements, into a legally binding international standard is pressing.

Another point that needs to be addressed at a regulatory level is the use of LNG as a fuel by inland vessels. Under the present regulatory framework for inland shipping in Europe, the use of LNG as a marine fuel is not allowed. The EU has recognized that, if LNG use in European inland waterways were to be allowed, this would help to improve the economies of scale for LNG provision in those ports that have both sea and inland waterway access.

It is apparent that further advancement of LNG as a marine fuel relates to three factors: the development of adequate bunkering infrastructure, the building of new ships (or modification of existing ones), and the establishment of an adequate and comprehensive regulatory framework. The first two factors constitute the two sides of the chicken-and-egg problem. As indicated in this article, the numbers and types of vessels opting for LNG as the fuel of choice are on the increase. Several ports have adopted rules to regulate the bunkering of LNG as a marine fuel while others have plans to do so in the not-too-distant future.

The entry into force of stricter limits on sulfur content in marine fuel will help further consolidate the status of LNG as a marine fuel. As progress continues, it is clear that the last hurdle to be surpassed to ensure the status of LNG as an important marine fuel is the establishment of an adequate regulatory framework at the international level. This framework needs to adequately cover both the gas-fueled vessel itself and all aspects of the associated bunkering process. While port regulations and rules issued by various classification societies have been playing an important interim role, it is crucial that the draft IGF Code come into legal force sooner rather than later. Only when that happens can a satisfactory level of uniformity be attained. While it is clear that the regulatory framework will need to be revisited and updated, this is a process that can take place after entry into force as industry experience with LNG use increases.

Acknowledgments

This article, which examines the regulatory regimes in relation to the use of LNG as a marine fuel, is based on a more lengthy report prepared for the SAIL Project. The report ("The International Legal Framework in Relation to the Use of LNG as a Marine Fuel") forms part of Work Package 5 of the SAIL Project, which has as its aim the review of applicable policy and the development of recommendations in relation to the building and operation of hybrid sailing ships.

Notes

1. In 2007, for example, it was estimated that shipping was responsible for the emission of 870 million tonnes of carbon dioxide, which was roughly 3.3% of the global emissions that year. See International Maritime Organization (IMO), "Second IMO GHG Study 2009" (April 2009), available at the IMO Web site, www.imo.org.
Troublingly, the study concluded that midrange emissions scenarios show that by 2050, in the absence of policies, carbon dioxide emissions from international shipping may grow by a factor of 2 to 3 (compared to 2007) as a result of the growth in shipping. See also Manchester University, "High Seas, High Stakes," final project report (2014), available at www.lowcarbonshipping.co.uk/files/ucl_admin/High_Seas_High_Stakes_High_Seas_Project_Final_Report.pdf. While confirming that global shipping emissions are generally estimated to account for around 3% of global carbon dioxide emissions, the IMO report indicates that more reliable methods could be utilized to carry out such assessments.

2. A. J. Dore et al., "Modelling the Atmospheric Transport and Deposition of Sulphur and Nitrogen over the United Kingdom and Assessment of the Influence of SO_2 Emissions from International Shipping," 41 *Atmospheric Environment* (2007): 2365. The authors comment that "enforcing the MARPOL convention to restrict the sulphur content of bunker fuel used by international shipping in the North Sea from 1.5% to 1%. . . would result in a 6% reduction in total sulphur deposition to the UK for the year 2020."

3. *Lloyd's Register*, "LNG-Fuelled Deep Sea Shipping: The Outlook for LNG Bunker and LNG-Fuelled Newbuild Demand Up to 2025" (August 2012), available at www.lr.org/Images/LR%20bunkering%20study_Final%20for%20web_tcm155-243482.pdf.

4. *Ibid*.

5. The benefits of utilizing LNG as a marine fuel extend beyond LNG being the more environmentally friendly option. LNG is also cheaper than the low sulfur fuels that will be required to comply with the new sulfur requirements that have entered into force or will progressively enter into force over the next few years. European Commission, Staff Working Document, "Action Towards a Comprehensive EU Framework on LNG for Shipping (SWD

(2013) 4 final)," (Brussels, 24 January 2013), available at eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2013:0004:FIN:EN:PDF. At 1, it is observed that:

> even based on today's (July 2012) landed prices for LNG (300–410 EUR/tonne in the EU), it potentially provides a viable alternative to the use of heavy fuel oil (480 EUR/tonne) and even more in SECAs which from 2015 will require the use of ultra-low sulphur marine gasoil (730 EUR/tonne). Once a viable spot market for LNG for shipping is established, prices might drop even further (prices in the US are as low as 90 EUR/tonne).

6. Det Norske Veritas, "Shipping 2020," executive summary of the report is available at www.dnv.com/binaries/1shipping%202020%208%20pages%20summary%202012%2006%2004_tcm4-518883.pdf.

7. See "World's First LNG-Ready Ultra Large Container Ship Named," *Maritime Today*, 15 September 2014.

8. See "Viking Grace," available at www.vikinggrace.com/about/.

9. The International Convention for the Prevention of Pollution from Ships, as modified by the Protocol of 1978, as amended 1340 U.N.T.S. 61.

10. See the subsection "EU Measures."

11. Protocol of 1997 to Amend the MARPOL Convention, IMO Doc. MP/CONF.3/34 (October 1997).

12. See, generally, Proshanto K. Mukherjee and Jingjing Xu, "The Legal Framework of Exhaust Emissions from Ships: A Selective Examination from a Law and Economics Perspective," in *Impacts of Climate Change on the Maritime Industry*, ed. Neil Bellefontaine and Olof Linden (Malmö: World Maritime University, 2009), 69–101.

13. IMO, Marine Environment Protection Committee (MEPC), Resolution MEPC.176(58), 10 October 2008, "Revised MARPOL Annex VI," available at the IMO Web site, supra note 1.

14. *Ibid.*, reg. 14(1).

15. *Ibid.*, Appendix III, defines the objective of sulfur oxide Emission Control Areas (SECAs) as being that of preventing, reducing, and controlling air pollution from SO_x emissions from ships and their attendant adverse impacts on land and sea areas.

16. Alan Khee-Jin Tan, *Vessel-Source Marine Pollution: The Law and Politics of International Regulation* (Cambridge: Cambridge University Press, 2006), 160.

17. UK Chamber of Shipping, "Report on Impact of Sulphur Targets" (2013), concluded that retrofitting ships to make them LNG compatible would, in practice, be "unsuitable for much of the UK fleet given the age and configuration of existing ships." It is clear that the greatest potential for the use of LNG as a marine fuel lies with regard to vessels that are to be constructed. Report is available at www.ukchamberofshipping.com/media/filer/2013/03/08/amec_uk_chamber_of_shipping_report_on_impact_of_2015_sulphur_targets.pdf.

18. IMO, MEPC Resolution, MEPC.203(62) (15 July 2011), available at the IMO Web site, supra note 1.

19. A study commissioned by the IMO found that an estimated 151.5 million tonnes of carbon dioxide reductions per year can be expected by 2020 as a result of these measures, with the amount set to increase to an average of 330 million tonnes annually by 2030. See IMO, "Study Shows Significant Reductions in CO_2 Emissions from Ships from IMO Measures," available the IMO Web site, supra note 1.

20. See IMO, press briefing, "Mandatory Energy Efficiency Measures for International Shipping Adopted at IMO Environment Meeting," available at the IMO Web site, supra note 1.

21. Protocol to the United Nations Framework Convention on Climate Change, 37 *I.L.M.* 22 (1998), Article 2(2).

22. "2012 Guidelines on the Method of Calculation of the Attained Energy Efficiency Design Index (EEDI) for New Ships," MEPC Resolution, MEPC. 212(68) (2 March 2012), available at the IMO Web site, supra note 1. See also the guidance for implementation of the EEDI issued by Lloyd's Register, "Implementing the Energy Efficiency Design Index," available at www.lr.org/Images/EEDI%20Guidance%20Notes%20for%20Clients%20v3.0_tcm155-240648.pdf.

23. "2012 Guidelines for the Development of a Ship Energy Efficiency Management Plan (SEEMP)," MEPC Resolution, MEPC. 213(63) (2 March 2012), available at the IMO website, supra note 1. See also the SEEMP template for owners and operators issued by *Lloyd's Register*, available at www.lr.org/Images/LR%20SEEMP%20template%20v2.2_tcm155-240650.pdf.

24. See *ibid.*, sec. 3.5.

25. *Ibid.*, sec. 5.35.

26. See, for example, “Proposal for a Regulation of the European Parliament and of the Council on the Monitoring, Reporting and Verification of Carbon Dioxide Emissions from Maritime Transport and Amending Regulation (EU) No 525/2013,” COM (2013) 480 final (28 June 2013). In the explanatory memorandum, it is noted that “[t]he proposed Monitoring, Reporting and Verification (MRV) system could be converted into a global system with only limited adjustments.. . .”

27. Council Directive 1999/32/EC of 26 April 1999 Relating to a Reduction in the Sulphur Content of Certain Liquid Fuels and Amending Directive 93/12/EEC (OJ L 121, 11.5.1999, p. 13), as amended by Directive 2005/33/EC and Directive 2012/33/EU, hereinafter referred to as the amended Directive 1999/32/EC.

28. When setting the sulfur limits, the EU recognized that complying with the legislation can be costly for the shipping industry which, in turn, would impact on the competitiveness of short-sea shipping in comparison with other transport modes. Since a shift to land transport would defeat the overall aim of reducing harmful emissions, discouraging short-sea shipping was something that the EU was eager to avoid. To this effect, in Directive 2012/22/EU, a new article is introduced, which allows member states to adopt financial measures to help operators affected by the new sulfur limitations, provided that such measures comply with EU rules on state aid.

29. European Commission, “COM(2013) 479 Final: Integrating Maritime Transport Emissions in the EU’s Greenhouse Gas Reduction Policies.”

30. See European Commission, “SWD(2013) 4 Final: Action Towards a Comprehensive EU Framework on LNG for Shipping” (January 2013). In Section 1, it is remarked that “LNG is the most promising alternative shipping fuel technology in the short to medium term, at least for short sea (and possibly inland waterway transport), but also for maritime activities outside transport, e.g. fisheries and offshore services.”

31. With regard to reduction of greenhouse gas emissions, on the other hand, the EU has recognized that the adoption of LNG on its own would be insufficient to solve the problem and, thus, additional measures need to be adopted in conjunction with the potential use of LNG as a marine fuel.

32. “Action Towards a Comprehensive EU Framework on LNG for Shipping,” supra note 30, Section 1, notes that “[t]he economic factors, once LNG takes up in SECAs, can also prevail and promote the use of the bunker in other areas across the EU.”

33. Central Commission for the Navigation of the Rhine, “Rhine Vessels Inspection Regulations.” The first Rhine Vessel Inspection Regulations (RVIR) date back to 1905, with the most recent revisions made in 1976, 1995, and 2006. The regulations set out the technical requirements that vessels need to fulfill to navigate on the Rhine. Requirements deal with the stability, strength, maneuverability, and equipment of vessels.

34. Directive of the European Parliament and of the Council of 12 December 2006 laying down technical requirements for inland waterway vessels and repealing Council Directive 82/714/EEC. This directive aims to improve European river transport by attaining technical harmonization of vessels. It aims to lay down a high level of safety equivalent to that for shipping on the Rhine.

35. The European Agreement Concerning the International Carriage of Dangerous Goods by Inland Waterways (ADN) done at Geneva on 26 May 2000 on the occasion of a diplomatic conference held under the auspices of the United Nations Economic Commission for Europe (UNECE) and the Central Commission for the Navigation of the Rhine (CCNR). It entered into force in February 2008.

36. The development of the CCNR’s Internet platform is intended to make more readily available comprehensive information on the status of relevant projects. It is hoped that this will help to reduce the uncertainty that presently surrounds the utilization of LNG as a marine fuel in inland waterways, a result that should be welcomed by public and private decision makers alike. See www.inland-navigation.org/observatory/innovation-technologies/lng/lng-database/.

37. “Action Towards a Comprehensive EU Framework on LNG for Shipping,” supra note 30.

38. International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (16C Code), IMO, Maritime Safety Committee (MSC), Resolution MSC.5(48) (17 June 1983), available at the IMO Web site, supra note 1.

39. International Convention for the Safety of Life at Sea, 1184 *U.N.T.S.* 2, as amended.

40. Norway, “Proposal for Developing International Regulations on Gas-Fuelled ships,” IMO Doc. MSC 78/24/8 (19 December 2003), available at the IMO Web site, supra note 1.

41. "Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships," MSC Resolution MSC. 285(86), (17 June 2009), available at the IMO Web site, supra note 1.

42. *Ibid.*, Preamble, para. 2.

43. "International Standards" are defined in *ibid.*, sec. 1.3.26, as "applicable international or national standards acceptable to the Administration or standards laid down and maintained by an organization which complies with the standards adopted by the Organization and which is recognized by the Administration."

44. The draft IGF Code, together with proposed amendments to make the code mandatory under SOLAS, were agreed to at the inaugural session of the Sub-Committee on Carriage of Cargoes and Containers (CCC 1) in September 2014. The text of the draft IGF Code is contained in CCC 1/13/Add.1, available at the IMO Web site, docs.imo.org/Shared/Download.aspx?did=89263.

45. *Ibid.*, sec. 17.1.1.

46. *Ibid.*, sec. 17.2.1, determines that "[t]ests related to welding and tank testing shall be in accordance with the IGC Code sections 4.10 and 4.11."

47. International Convention on Standards of Training, Certification and Watchkeeping for Seafarers, 1361 *U.N.T.S.* 2, as amended.

48. "Report of the Maritime Safety Committee on its Ninety-Second Session," IMO Doc. MSC 92/26 (30 June 2013), 58.

49. For an in-depth examination of the gaps that are not tackled by the IGF Code, see European Maritime Safety Agency, "Study on Standards and Rules for Bunkering of Gas-Fuelled Ships," available at emsa.europa.eu/emsa-documents/download/2118/1714/23.html.

50. The contention that inadequate bunkering infrastructure constitutes a major obstacle to the adoption of LNG as a marine fuel was corroborated by a recent review undertaken at the University of Antwerp of 33 published studies on the use of LNG as a ship fuel. Almost all of the reviewed studies showed "a consensus that a critical challenge to the development of LNG as a ship fuel is the current lack of established bunkering infrastructure." See Siyuan Wang and Theo Notteboom, "LNG as a Ship Fuel: Perspectives and Challenges," *Global Issues* 60 (November 2013), available at www.porttechnology.org/images/uploads/technical_papers/LNG_LR.pdf.

51. *Lloyd's Register*, supra note 3.

52. This percentage is based on the replies of the 13 ports that responded to the questionnaire. *Ibid.*

53. European Commission, "Com (2013) 18 Final: Proposal for a Directive of the European Parliament and of the Council on the Deployment of Alternative Fuels Infrastructure." The Preamble recognizes LNG as "an attractive fuel alternative for vessels to meet the requirements for decreasing the sulphur content in maritime fuels in the Sulphur Emission Control Areas, affecting half of the ships sailing in European Short Sea Shipping."

54. EMSA, supra note 49, at 69 onward.

55. Draft IGF Code, supra note 44, Article 19.3.1 provides that: "[t]he responsibility and accountability for the safe conduct of the bunkering operation are jointly shared between the Master of the receiving vessel and the Master of the bunkering vessel or representative of the bunker station. . . ."

56. This is so even if *ibid.*, art. 19.2.1.3, provides that "the ship shall be provided with a suitably detailed fuel transfer manual. . . [which must] include but is not limited to: overall operation of the ship from dry-dock to dry-dock, including procedures for system cool down and warm-up, bunker loading and, where appropriate, discharging, sampling, inerting and gas freeing."

57. The International Association of Oil and Gas Producers, "OGP Draft 118683: Guidelines for Systems and Installations for Supply of LNG as Fuel to Ships," available at *www.ogp.org.uk/index.php/download_file/view/473/2876*, hereinafter referred to as the ISO Guidelines.

58. *Ibid.*

59. EMSA, supra note 49, at 69 onward.

60. Det Norske Veritas, "Gas Fuelled Installations" (January 2001), available at exchange.dnv.com/publishing/rulesship/2002-07/ts613.pdf.

61. DNV has played an important role in promoting and enabling the utilization of LNG as a marine fuel. This classification society classed Norway's first LNG-fueled vessel (which has been in operation since 2000) and claims to class more than 90% of all LNG-fueled vessels. See, for example, www.dnv.com/press_area/press_releases/2013/dnv_plays_an_active_role_in_introducing_lng_as_ship_fuel_in_germany.asp.

62. Bureau Veritas, "Safety Rules for Gas-Fuelled Engine Installations in Ships" (May 2011), available at www.veristar.com/portal/rest/jcr/repository/collaboration/sites%20content/live/veristar info/web%20contents/bv-content/generalinfo/giRulesRegulations/bvRules/rulenotes/documents/4707.9.529NR_2011-05.pdf.

63. American Bureau of Shipping, "Guide for Propulsion and Auxiliary Systems for Gas Fuelled Ships" (May 2011), available at www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA%20Repository/Rules&Guides/Current/181_GasFueledShips/Guide.

64. EMSA, supra note 49, at 29.