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LNG-Powered Ships:
Environmental Advantages to Building LNG-Powered Vessels

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Introduction: LNG as Ship Fuel -- An Idea Whose Time Has Come?

Liquefied natural gas (LNG) is essentially methane gas, liquefied when cooled down to a temperature of -162 degrees C. In liquid form, it can be transported in storage tanks. For many years, LNG has been carried as cargo aboard vessels. On these carriers, boil-off from the cargo has often been used as propulsion fuel. That trade seems destined to continue and grow as the worldwide market for LNG expands.

But now there is new idea: Why not use LNG as fuel to operate ships – not just the ships that carry LNG as cargo, but other classes of cargo vessels too, particularly container ships, as well as cruise ships and other watercraft (ferries, tugs, offshore supply vessels, etc.)? Already, countries like Germany and Norway are introducing LNG-propelled vessels or dual-fuelled ships into their national fleets, and other countries, including the USA and Canada, are studying the matter seriously, in conjunction with the International Maritime Organization (IMO) and the major classification societies. The reasons and motives driving this new idea are clear: environmental protection and fuel costs. A rudimentary regulatory framework already exists on the international level, and a more detailed one, designed to become mandatory, is under development for eventual adoption by countries, including Canada. This innovation in shipping offers much promise for the future.

Air Pollution Restrictions

The attraction of LNG as ship fuel today largely results from the introduction over the last decade of new international and mational standards on air pollution from ships.

MARPOL 1973/78, with its 1997 Protocol, now includes Annex VI on Prevention of Air Pollution from Ships,[1] revised by IMO's Marine Environment Protection Committee with effect from 2008.[2] This Revised Annex VI restricts the global sulphur oxide (SOx) limit

[1] MARPOL Annex VI, Regulations for the Prevention of Air Pollution from Ships, Regulation 14 re sulphur oxide emissions**,** in force as of May 19, 2005 and Regulation 13 on nitrogen oxide emissions.
[2] See MEPC 176(58), adopted in July 2005 and in force October 2008.

of ship fuel from 4.50% to 3.50% effective January 1, 2012, then progressively, year by year, to 0.50% effective from January 1, 2020.

In addition, "Emission Control Areas" providing even more rigorous controls on SOx in certain waters have been introduced. In ECAs, the maximum sulphur oxide content of ship fuel will be reduced from 1.0% (the maximum allowed since July 1, 2010) to 0.1%, effective January 1, 2015.[3] There will also be restrictions on nitrogen oxide (NOx) emissions, which will be capped at the more rigorous Tier III level by January 2016, and on particulate matter (smoke and soot emitted by the smokestacks of vessels).

The first Sulphur Emissions Control Areas (SECAs) were established for the Baltic and North Seas in 2005 and 2006.

In 2009, Canada, the United States and France (with respect to the islands of Saint-Pierre and Miquelon) proposed to the International Maritime Organization ("IMO") that a North American Emissions Control Area be designated.[4] IMO did so on March 26, 2010. The North America ECA wraps around the coasts of Canada and the U.S.A. (including southeast Alaska and the main Hawaiian islands) and extends some 200 n.m. from the coastline, below 60 degrees north latitude.

The North American ECA came into force internationally as of August 1, 2012, but its implementation was delayed in Canada, pending further consultations with stakeholders by Transport Canada, during which time interim measures were applied. The ECA finally came into force for Canada as of April 18, 2013, pursuant to the *Regulations Amending the Vessel Pollution and Dangerous Chemicals Regulations*,[5] adopted under the *Canada Shipping Act, 2001*.[6]

The United States has given effect to the MARPOL Annex VI provisions and the North Amercian ECA under the *Maritime Pollution Prevention Act of 2008*[7] amending the *Act for the Prevention of Pollution from Ships* (APPS),[8] which legislation is administered through Regulations[9] applied by the Environmental Protection Agency (EPA).

A US Caribbean Sea ECA has also been approved, and is expected to be implemented in 2014, in the waters off Puerto Rico and the U.S. Virgin Islands.[10]

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[3] See generally IMO, "Air Pollution from Ships"; online at: http://www.imo.org/OurWork/Environment/PollutionPrevention/AirPollution/Pages/Air-Pollution.aspx .

[4] See Proposal to Designate an Emissions Control Area for Nitrogen Oxides, Sulphur Oxides and Particulate Matter, submitted by the United States and Canada, IMO Document MEPC59/6/5, April 2, 2009, approved in principle by the IMO, July 17, 2009.

[5] SOR/2013-68, *Canada Gazette*, Part II, Vol. 147, No. 10, May 8, 2013, p. 919.

[6] S.C. 2001, c. 26, subsects. 35(1), 120(1) and (2), sect. 190 and paragraphs 207(2)(a) and 244(a).

[7] Public Law 110-280 of July 21, 2008, 122 Stat. 2611.

[8] 33 U.S.C. 33, as amended by the *Marine Pollution Prevention Act of 2008* and 40 C.F.R. 1043.

[9] 40 C.F.R. 1043.

[10] The IMO designated the US Caribbean Sea ECA on July 15, 2011 by way of amendments to MARPOL's Annex VI, which came into force January 1, 2013, but the ECA itself will take effect as of January 1, 2014.

In the European Union, Council Directive 1999/32[11] as amended by Council Directive 2005/33,[12] has already imposed a 0.1% sulphur limitation on vessel fuel emissions for ships within E.U. ports for longer than two hours and on E.U. inland waterways.[13] On November 21, 2012, the European Parliament and the Council enacted Directive 2012/33/ amending Council Directive 1999/32,[14] in order to give full effect to MARPOL's Annex VI in the EU. Member States are required to bring their laws and regulations into conformity with the Directive by June 18, 2014.

California, through its Air Resources Board, has initiated similar restrictions, which are to become more rigorous in 2012, requiring the use of marine gas oil (MGO) or marine diesel oil (MDO) with a sulphur content at or below 0.1%.[15]

Outside the North American ECA, the "global" limit of sulphur content of ship fuel for Canadian and foreign vessels of 400 gross tons or more is 3.5% from January 1, 2012 to December 31, 2019, after which it will be reduced to 0.5%. Canadian vessel owners operating on the Great Lakes and St. Lawrence must comply with a sulphur content limit of 1.3% in 2013, declining progressively on January 1 of each year until it reaches 0.1% on January 1, 2020. Other options include switching to low-sulphur fuel, installing gas exhaust cleaning systems ("scrubbers") or "fleet averaging", whereby the annual fuel limits may be exceeded by a maximum cumulative amount of 0.4% before 2017, declining until 2020.[16] Those regulations relating to the Great Lakes and St. Lawrence waterways generally correspond to those of the United States.

Advantages of LNG as Ship Fuel

There are four basic motivations for using LNG as ship fuel:[17]

1) LNG cuts down significantly on sulphur oxide (SOx) emissions, by as much as 90 to 95 percent, if not totally. Nitrogen oxide (NOx) emissions can also be cut by about

[11] Council Directive 1999/32 of April 26, 1999 on Sulphur Content of Liquid Fuels.
[12] Council Directive 2005/33 of July 6, 2005.
[13] On July 1, 2010, this requirement was extended into the offshore areas of the Baltic and North Sea. See U.K. P. & I. Club, "MARPOL Annex VI and Air Pollution", online at: http://www.ukpandi.com/knowledge-developments/industry-developments/marpol-annex-vi-air-pollution/
[14] OJEC 27.11.2012, L. 327/1. For full text, see:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2012:327:0001:0013:EN:PDF.
[15] "Airborne Toxic Control Measure for Fuel Sulphur and other operational Requirements of Ocean-going Vessels within Californian Waters and 24 Nautical Miles of the Californian Baseline", 17 CCR, Section 93118.2, Title 17. For a brief summary of the IMO, EU and California sulphur controls on ship fuel, see Germanischer Lloyd, "Customer Information: New sulphur limits in marine fuel – guidance for maintaining engine and boiler safey and availablility", Germanischer Lloyd AG, 2009-11-03, Revision 1.
[16] See Canadian *Regulations Amending the Vessel Pollution and Dangerous chemicals Regulations*, SOR/2013-68, *supra*.
[17] See Germanischer Lloyd, "Why LNG as Ship Fuel?" online at:
http://www.gl-group.com/en/snb/lng_benefits.php.

80% using LNG as fuel,[18] so as to comply with IMO Tier III limits, which will apply in ECAs from 2016.[19]

2) LNG also reduces carbon dioxide (CO2) emissions, by an estimated 20 to 25 percent, depending on the type of engine and the measures applied to reduce the release of unused methane, as well as particulate emissions.

3) LNG, when it leaks, evaporates into the air or on the surface of water. In consequence, its use as ship fuel reduces substantially the risk of marine pollution incurred with traditional fuel and the need for costly and demanding environmental clean-up operations when spills happen.[20] This consideration is of particular importance with respect to protecting the fragile marine environment of the Arctic in the event of increased shipping activity there in coming years resulting from global warming and the reduction of ice cover in those Northern waters.

4) Prices for LNG may well make it a more affordable fuel for shipowners, costing an amount comparable to heavy fuel oil (HFO), giving LNG a commercial appeal if the cost of other types of fuel continues to rise in the coming years. In particular, the hope is that LNG bunkers would compare favourably in cost with low-sulphur marine gas oil (MGO), which is the only other fuel suitable for use in Emission Control Areas if no other technical measures are implemented to reduce SOx emissions.[21] The seeming abundance of shale gas in North America offer the prospect of prices remaining low for the foreseeable future, thus encouraging shipowners to build LNG-propelled newbuildings or retrofit their existing vessels to operate wholly or partly on LNG.[22]

The Danish Government, in a recent study produced in cooperation with the E.U., has concluded that LNG is the most cost-effective solution whereby shipowners can meet coastal emission controls, even considering the high costs of building LNG terminals to

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[18] See Oskar Levander, « The Green Answer", World Cruise Network, September 1, 2006, online at: http://www.worldcruise-network.com/features/feature687/.

[19] MARPOL 1973/78, Annex VI, Regulation 13.

[20] See Center for Liquefied Natural Gas, FAQ at http://www.lngfacts.org/about-lng/faq/. and California Energy Commission, "Liquefied Natural Gas (LNG) as a Transportation Fuel" at http://www.consumerenergycenter.org/transportation/afvs/lng.html,
stating: "When cold LNG comes in contact with warmer air, it creates a visible vapor cloud from condensed moisture in the air. As it continues to get warmer, the vapor cloud becomes lighter than air and rises. When the vapor mixes with air, it is only flammable when the mixture is between 5-15 percent natural gas. When the mixture is less than 5 percent natural gas it doesn't burn. When the mixture is more than 15 percent natural gas in air, there is not enough oxygen for it to burn."

[21] The decision to use LNG as fuel as opposed to installing exhaust gas cleaning systems (« scrubbers ») to reduce emissions will depend on the price differential between LNG and heavy fuel oil (HFO), the time spent operating within ECAs and the starting year for the vessel. Most LNG systems are expected to become profitable in 2020, when the lowest sulphur content regulations come into force. See Germanischer Lloyd's "LNG as ship fuel – Will it be cost-effective?" at http://www.gl-group.com/en/group/lng_cost.php.

[22] See "The Rush to LNG", The Maritime Executive, March 15, 2013, at:
http://www.maritime-executive.com/article/The-Rush-to-LNG/. The article notes that the present price of LNG in the U.S.A. is about $2.40 per mcf, with the costs of liquefaction at only about $3.00 per mcf. Shell has made an agreement with the marine engineer manufacturer Wartsila to supply it with LNG at a low cost, in order to encourage the use of the new fuel in more vessels under construction.

facilitate bunkering.[23] LNG as fuel may also prove more economical than installing exhaust gas cleaning systems ("scrubbers") on vessels to reduce emissions from traditional heavy fuel oil (HFO), particularly if LNG proves less expensive than HFO going forward.[24]

The International Regulatory Framework

Interim Guidelines

Based on a proposal by Norway tabled in 2004, the IMO adopted voluntary "Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships" in 2009.[25] These non-binding Interim Guidelines address topics such as:

Ship arrangement and system design;
Fire safety;
Electrical systems;
Control, monitoring and safety systems;
Compressors and gas engines;
Manufacture, workmanship and testing (of gas tanks, gas piping systems, valves).
Operational and training requirements.

IGF Code

At the present time, the IMO's Sub-Committee on Bulk Liquids and Gases ("BLG"),[26] is busy developing an "International Code of Safety for Ships Using Gases or Other Low Flashpoint Fuels" (the "IGF Code").[27] The IGF Code will cover not only LNG as fuel for vessels, but other low flashpoint fuels as well (e.g. ethanol and methanol). The intention is to make the new Code mandatory, by adopting it as an amendment to the Safety of Life at Sea Convention (SOLAS) replacing the Interim Guidelines of 2009.[28]

Progress was made by the BLG Sub-Committee at its 17th session in London, from February 4 to 8, 2013 on drafting both the Code and the necessary amendment to

[23] See "Danes back LNG as fuel", TradeWinds, January 13, 2012 at p. 56.
[24] In the U.S., Washington State Ferries, operating 21 ferries out of Seattle, has studied using LNG-powered ferries, finding them both practical and cost-effective, offering the prospect of savings of some US $870,000 a year based on 2010 prices. See The Maritime Executive, "Is LNG the Fuel of the Future?" at: http://www.maritime-executive.com/article/is_lng-the-fuel-of-the-future.
[25] MSC 285(86), June 1, 2009.
For the text, see http://www.imo.org/blast/blastDataHelper.asp?data_id=25897&filename=285(86).pdf.
[26] This "BLG" Sub-Committee is a sub-committee of the IMO's Maritime Safety Committee ("MSC").
[27] This Code also seems to be known, perhaps for short, as the "International Code of Safety for Gas-Fuelled Ships".
[28] See "DEVELOPMENT OF INTERNATIONAL CODE OF SAFETY FOR SHIPS USING GASES OR OTHER LOW FLASHPOINT FUELS: Proposal for making the IGF Code mandatory submitted by Germany", BLG 16/6/4, November 25, 2011; online at: http://www.amtcc.com/imosite/meetings/IMOMeeting2012/BLG16/BLG%2016-6-4.pdf.

SOLAS, and a correspondence committee was struck to finalize the work.[29] The original plan was to have the IGF Code ready in final form for adoption by the IMO's Maritime Safety Committee at the same time as the planned revision of SOLAS in 2014, but it now appears that the drafting of the Code may not be completed before 2015, the year when the rigorous 0.1% fuel sulphur limit takes effect in the various ECAs.[30]

Among the topics to be addressed by the proposed IGF Code are:

A safety assessment to be done by shipowners and designers and submitted to the national maritime administration;
Ship design and construction standards;
Equipment for LNG-fuelled vessels;
Crew training (especially re the safe handling of LNG and bunkering procedures);
Bunkering procedures.

No doubt, the Code will reflect, to a large extent, the Interim Guidelines that it will replace, and perhaps also the input of the major classification societies.

The Contribution of Classification Societies

Certain classification societies have made a major contribution to developing an international legal framework for LNG-powered ships. The American Bureau of Shipping, for example, in May 2011, released the "ABS Guide for Propulsion and Auxiliary Systems for Gas Fueled Ships".[31]

Much like the Interim Guidelines and the still-embryonic IGF Code, the ABS Guideliness address:

Ship arrangement and system design;
Gas fuel storage;
Fuel bunkering systems;
Fuel gas supply systems;

[29] See "Sub-Committee on Bulk Liquids and Gases (BLG): 17th session, 4 to 8 February 2013, dated February 8, 2013, at:
http://www.imo.org/MediaCentre/MeetingSummaries/BLG/Pages/BLG-17th-session.aspx. See also Germanischer Lloyd, GL Focus- Regulatory and Technical Update, "BLG made progress on IGF Code and amended IBC", dated February 14, 2013, at:
www.gl-group.com/pdf/GL_Focus_News_**BLG_17**_-_2.pdf.

[30] At the same time, the BLG Sub-Committee is revising the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (the IGC Code).

[31] For the text, see
http://www.eagle.org/eagleExternalPortalWEB/ShowProperty/BEA%20Repository/Rules&Guides/Current/181_GasFueledShips/Guide. These Guidelines were developed in consideration of IMO's Interim Guidelines on Safety for Natural Gas-Fuelled Engine Installations in Ships and the work in progress on the proposed IGF Code. The Guidelines also aim at consistency with the International Code for the Construction and Equipment of Ships Carrying Liquefied Gases in Bulk (IGC Code), another IMO instrument.

Re-liquefaction system;
Gas combustion units
Dual fuel and single gas fuel engines;
Gas turbines;
Surveys after construction.

Germanischer Lloyd has published its "Guidelines for the Use of Gas as Fuel for Ships" in 2010, which follow closely IMO's Interim Guidelines of 2009.[32]

Lloyd's Register also developed its own "Rules and Regulations for the Classification of Natural Gas Fuelled Ships", published in July 2012.[33]

Regulatory Challenges Posed by LNG-Burning Ships

There are at least three main regulatory challenges now confronting those seeking to lay down rules for the use of liquefied natural gas as a fuel for vessels:

1) ship design

Because LNG is less dense than petroleum, LNG tanks take up significant space on vessels. Compared with marine diesel oil (MDO), an equal energy content of LNG requires about 1.8 times more volume. Adding tank insulation, and noting the maximum filling ratio of 95%, the required volume increases to about 2.3 times.[34] The main issue connected with this storage question is where the LNG tanks should be located, and, in particular, whether they should be placed under accommodations and how close they should or should not be located to the sides of the vessel. This is an issue of special relevance to cruise ships, although it also is a source of concern for container vessels. The matter has been one of the bones of contention bedeviling the drafting of the long-awaited IGF Code, but one senses that a solution will be found.

2) bunkering

The potential financial viability of LNG-propelled vessels in both national and international trade will depend, to some degree, on whether supplies of the fuel can be organized effectively. Norway is the most advanced country in the use of LNG-propelled vessels, with about 20 such ships now in service, largely as ferries or offshore supply vessels. Norway has built a network of points along its coast where such ships can refuel. Other countries lack such elaborate infrastructure. There are solutions, however. Small LNG bunkering vessels can be built and put into service, but that, of course, entails additional expenditures and time. Another solution is delivery of LNG by tanker trucks or bunkering via pipelines. Bunkering procedures will have to be regulated, so as to lessen

[32] See http://www.gl-group.com/infoServices/rules/pdfs/english/ergvors/teil-3/kap-1/englisch/inhalt.pdf.
[33] See http://www.webstore.lr.org/products/481-rules-and-regulations-for-the-classification-of-natural-gas-fuelled-ships-july-2012-notice-no1.aspx.
[34] See Oskar Levander, "The Green Answer", *supra* at http://www.worldcruise-network.com/features/feature687.

the danger of fire if some of the gas escapes during the process and encounters a source of ignition. The Danish government report mentioned above, however, expresses the view that even if it were necessary to build special terminals to facilitate bunkering, the long-term economic benefits of using LNG as fuel would amply justify the capital costs of such infrastructure.[35]

In Quebec, the Société des traversiers du Québec is having three new dual-energy (LNG/diesel) ferries built, which are due to go into service by the end of 2013 to connect Tadoussac with Baie Sainte-Catherine and Baie Comeau with Matane. Bunkering will be done by trucks operated by Gaz Métro Transport Solutions.[36]

The Port of Antwerp is collaborating with Den Norske Veritas to develop procedures for the safe bunkering of LNG-fuelled vessels in that major international port. The Port has also ordered a LNG bunkering barge capable to bunkering seagoing vessels. The new bunkering vessel is expected to be in service by 2015.[37] Hamburg is also planning an LNG bunkering facility for its Port.[38] The European Commission is pushing all European Union ports to have LNG refuelling infrastructure in place by 2020.[39]

Closer to home, Shell has announced plans to build a liquefaction plant at Sarnia, Ontario, capable of producing 1.5 million litres a day of LNG -- enough fuel to supply the entire Great Lakes fleet.[40]

3) crew training

For the same reason, the training of crews in the proper handling of LNG as fuel is essential. LNG, if spilled at -163 degrees C. could cripple steel structures and then evaporate, producing an inflammable gas cloud liable to catch fire if ignited.[41] Crew training would have to be stringently regulated, possibly by amendments to the STCW

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[35] See "Danes back LNG as fuel", TradeWinds, January 13, 2012 at p. 36. See also TradeWinds, "Calls for a safety code governing LNG as fuel", December 16, 2011 at p. 43.

[36] See:
http://www.ferryvolution.com/2012/08/15/this-is-the-new-camille-marcoux/and
http://www.gazmetrost.com/chef-file-en.html

[37] See "The Port of Antwerp announces another significant step forward in its LNG policy", Bunker Ports News Worldwide, April 6, 2013 at:
http://www.bunkerportsnews.com/News.aspx?ElementId=95231f56-6e9c-4645-9da2-cb493c75b5e9.
Antwerp is also chairing an international working group tasked with developing safe procedures for LNG bunkering in several major ports around the globe. Another major bunkering facility is being built in Gotheborg in Sweden.

[38] See Ship & Bunker, October 31, 2012, "LNG Terminal Planned for Port of Hamburg", at:
http://shipandbunker.com/news/emea/912103-lng-terminal-planned-for-port-of-hamburg.

[39] See Reuters, March 5, 2013, "Northern European ports spearhead move to gas as ship fuel", at:
http://www.reuters.com/article/2013/03/05/energy-gas-transport-idUSL6N0BS6ZM20130305.

[40] See "Shell aims to fuel Great Lakes freighters with liquefied natural gas", The *Globe and Mail*, March 5, 2013 at: http://www.theglobeandmail.com/report-on-business/industry-news/energy-and-resources/shell-aims-to-fuel-great-lakes-freighters-with-liquefied-natural-gas/article9282660/.

[41] See Germanischer Lloyd "LNG Bunkering" and "LNG Supply Chain" at http://www.gl-group.com/en/group/lng_bunkering.php and http://www.gl-group.com/en/group/lng_supp_chain.php.

Convention. But all of that is possible, and one suspects that it will happen, if LNG fuel grows in importance as a propulsion method for increasing numbers and types of vessels.

Canadian Regulation

Canada at present has no statute or regulations governing design, construction or operation of gas-propelled ships. Nevertheless, it seems clear beyond doubt that that subject, relating as it does to "Navigation and Shipping" within the meaning of sect. 91(10) of the *Constitution Act, 1867*, would lie within the exclusive jurisdiction of the federal Parliament and government, and outside the sphere of legislation of the provinces and territories.

At present Canada's *Marine Machinery Regulations*,[42] which are in force pursuant to the *Canada Shipping Act, 2001*,[43] limit ship engines, with few exceptions, to (diesel) fuel having a flash point of 60 degrees C.[44]

Canada is nevertheless following with the greatest interest developments at the international level relating to the regulation of LNG-propelled vessels and is a member of the IMO Sub-Committee on Bulk Liquids and Gases, where representatives of Transport Canada, in conjunction with those of other countries, are participating actively in the efforts to develop the expected IGF Code.

It is felt that if and when the IGF Code is ultimately adopted by the IMO, Canada will then have to determine what adaptations, if any, would be required before implementing the instrument domestically. It is quite possible that Canada would decide to apply the Code, together with any such amendments as might appear desirable, to all vessels operating in Canadian waters, including those of less than 500 grt, such as ferries and fishing craft.

In the meantime, pending the adoption and coming into force of the IGF Code in Canada, it is likely that any proposals for the building of LNG-powered Canadian vessels will be studied by Transport Canada Marine Safety, on a case-by-case basis, with ultimate decisions made by the Marine Technical Review Board, probably applying the IMO's Interim Guidelines and possibly those of one of the classification societies.

The potential introduction of LNG-powered ships into Canada is attracting ever greater interest. Lloyd's Register organized a seminar on the subject in Vancouver in June 2011, attended by over 100 delegates, including representatives of three marine engine builders, the Port Metro Vancouver, a local gas supplier, a shipyard, Transport Canada civil servants and the British Columbia Chamber of Shipping.[45]

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[42] SOR/90-264,
[43] S.C. 2001, c. 26, in force July 1, 2007.
[44] *Marine Machinery Regulations*, sect. 4 and Schedule XII, item 1.
[45] See Lloyd's Register, "LNG as Fuel seminar held in Vancouver", dated June 30, 2011, online at: http://www.lr.org/sectors/marine/News/223200-lng-as-fuel-seminar-held-in-vancouver.aspx.

The Most Recent LNG-fuelled Newbuildings

The work in progress at the IMO, coupled with the forthcoming more restrictive rules on air pollution in ECAs and the costs of marine diesel oil (MDO) and marine gas oil (MGO) (or of traditional heavy fuel oil – HFO - plus exhaust system "scrubbers") compared to LNG, may well motivate researchers and developers to meet these regulatory challenges in the near term.

One thing is clear, however. The world will not wait for the legislators to finish their drafting or for the designers to refine their designs or for the researchers to develop new technologies. With each passing month, additional LNG-powered vessels (or dual-powered ships) are either being ordered or being delivered, especially in Europe. Slowly but surely, these new and somewhat different-looking vessels are beginning to appear on the oceans of the planet. They are no longer just small coastal ferries and offshore supply vessels, but now include oceangoing ships of considerably greater tonnage to be used in international trade. A few examples suffice to make the point:

Germanischer Lloyd and IHI Marine United Inc. have signed an agreement to build a 13,000 TEU container vessel fuelled by LNG.[46]

The BIT VIKING, a 25,000 dwt product tanker, has been converted to a dual-fuel vessel capable of switching between fuel oil and LNG. The converted ship, classed by Germanischer Lloyd, and which began trading only on October 25, 2011, has already cut greenhouse gases by 20 to 25%, sulphur output entirely, NOx gases by 90% and particulate emissions by 99%.[47]

The world's first LNG-fuelled tanker, the MT ARGONON, a 6,100 dwt dual-fuelled chemical carrier, was delivered in Rotterdam in December 2011, for use in that country and beyond, in inland navigation on the Rhine and other European waterways.[48]

Meanwhile, up in Norway, Color Line has ordered a new LNG-powered ferry in March 2012, designed to carry up to 2000 passengers and 500 cars between Norway and Sweden.[49]

In the U.S., although innovation is slower than in Europe, two "dual-fueled" offshore supply vessels are now being built, according to the ABS Guidelines, for operation in the

[46] See Germanischer Lloyd, "LNG Solutions for Large Container Vessels the Focus of GL and IHIMU Joint Development Project" at http://www.gl-group.com/en/group/news_gl_ihimu_development_project.php.

[47] See Germanischer Lloyd, "World's first LNG fuelled product tanker now in service" at http://www.gl-group.com/en/press/news_lng_fuelled_bit_viking.php.

[48] See Lloyd's Register Group, "The world's first new LNG-fuelled tanker is classed by Lloyd's Register", at: http://www.lr.org/sectors/marine/future-shpping/fuels/argonon/..

[49] See "160m Norway-Sweden shuttle ferry" in http://www.ferryvolution.com/newbuilding-database/color-line/.

Gulf of Mexico.[50] Washington State Ferries, with assistance from DNV, is spending some US $75 million retrofitting six of its ferries to operate on LNG and expects a pay-back on that investment in seven years.[51]

Leading commentators predict that LNG will, in not too many years hence, become the fuel of choice in international shipping. It is not surprising, therefore, that *TradeWinds*, the international shipping newspaper, now carries, in every issue, a section on LNG, including frequent articles on its use as a marine fuel.[52]

Because of the high cost of the infrastructure needed to support a large-scale conversion to LNG as marine fuel, the key factor in the future use of that substance to power ships will likely be its cost. A senior Lloyd's Register market analyst has predicted that there could be some 653 vessels (tankers, cruise ships and container vessels) operating by 2025. If the fuel cost moves 25% lower than at present, that number could well rise to 1,960. But the study also suggests that if the fuel price increases by 25% against current prices, hardly any LNG-powered vessels will hit the water.[53]

Conclusion

Subject to relative cost stability, LNG-powered ships, and dual-fuel ships featuring LNG as one of their power sources, seem to be here to stay. They offer the promise of keeping the air over our oceans and rivers cleaner (thus improving public health), reducing the risk of costly pollution of waterways (a major anxiety as regards the Arctic in particular) and perhaps also saving considerable money for their owners and operators, compared to vessels powered by HFO (even when equipped with "scrubbers") or with MGO or MDO. The regulatory framework to govern LNG-propelled ships is just being erected now at the international level through the IMO, with the classification societies and some national maritime administrations (such as Transport Canada) assisting.

National adaptations of that framework, in Canada and elsewhere, will probably follow, hopefully in versions consistent with the international regime, so as to avoid conflicts of law and thus secure multilateral legal harmony in this new and exciting domain of maritime law.

LNG-propelled vessel may well prove to be a game-changer for the shipping industry, despite the uncertainties and challenges they pose for us today. Den Norske Veritas predicts that some 500 LNG-fuelled ships will be order by 2015,[54] and that LNG will

[50] See "ABS Harvey Gulf's Dual Fueled OSVs" at: http://www.marinelink.com/news/harvey-fueled-class341993.aspx.

[51] See "Washington State Ferries and DNV Explore LNG as a Fuel", February 5, 2013, at: http://gcaptain.com/washington-state-ferries-explore/.

[52] See, for example, "Eco Ambassador" in *TradeWinds*, March 22, 2013, at: http://www.tradewindsnews.com/tankers/314440/eco-ambassador.

[53] See "Price key to LNG as fuel", *TradeWinds*, Sept 3, 2012, at: http://www.tradewindsnews.com/liner/282740/price-key-to-lng-as-fuel.

[54] See "DNV Predicts Thousands of LNG Fuelled Ships by 2020" at:

dominate ship fueling within 40 years.[55] LNG fuel for vessels would appear to be an idea whose time has come, or, at any rate, is coming fast. We should prepare now to welcome these vessels on our waters and to enact the rules that their safe and environmentally-beneficial operation will demand, because, quite simply, they may well be the ships of tomorrow.

http://www.ngvglobal.com/dnv-predicts-thousands-of-lng-fuelled-ships-by-2020-1129.

[55] See Alaric Nightingale, in Bloomberg, "LNG to Dominate Ship Fueling Within 40 Years", November 19, 2010. See also The Maritime Executive, July 11, 2011, "Is LNG the Fuel of the Future?", at: http://www.maritime-executive.com/article/is-lng-the-fuel-of-the-future.