



Lloyd's Register & Gas Fuelled Ships

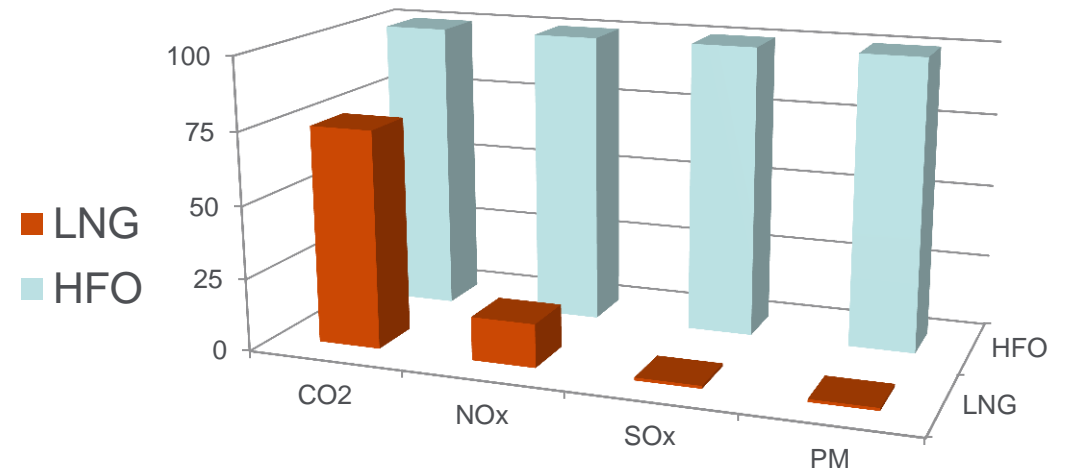
Fabrizio Cadenaro, LR Trieste TSO
1 July 2016

LNG as fuel for ships - Drivers

Environmental: Emission Control Areas (ECA, SECA) impose either the use of “clean” fuels or treatment of exhaust gas (or both)

Economical: price of LNG is competitive and may be even more in the long term

Availability & politics: Gas market & prices are somewhat detached from oil market

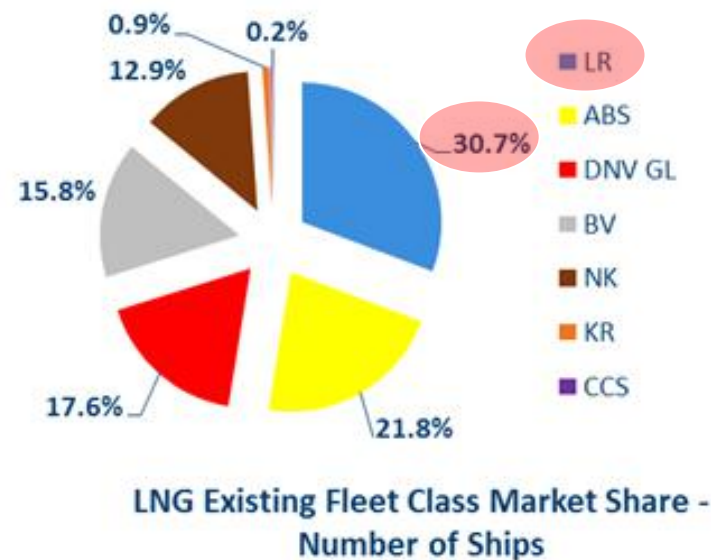


World gas fleet (carriers&GF ships) and LR position at glance

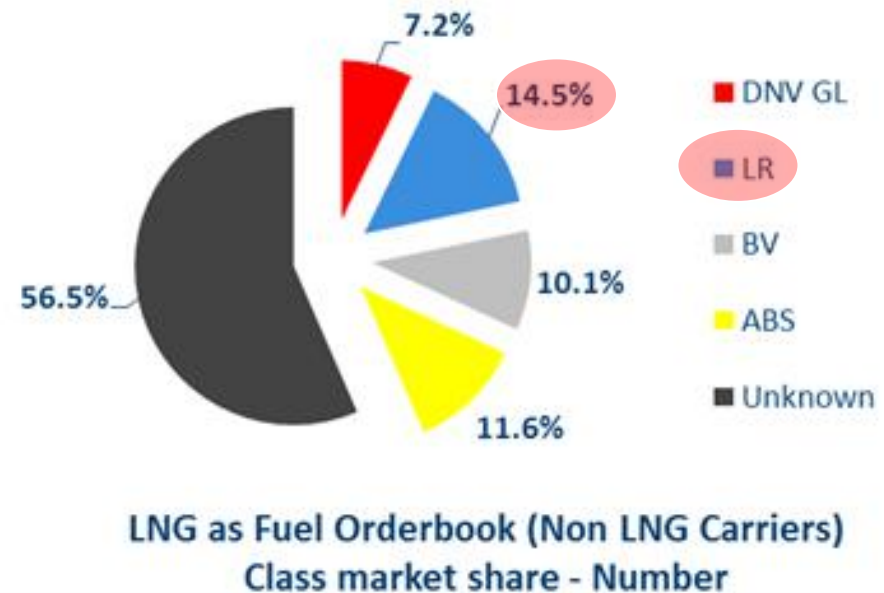
LNG carriers: world fleet 449 vessels in service (45.3mGT) and 139 on order (15.3 mGT).

Gas fuelled ship (non gas carriers): world fleet 87 vessels in service (1.15mGT) and 69 on order (1.45mGT)

LNG carriers: LR is **market leader**
in terms of classed ships (*).



Gas fuelled ship: LR is **leading the order book (**)**

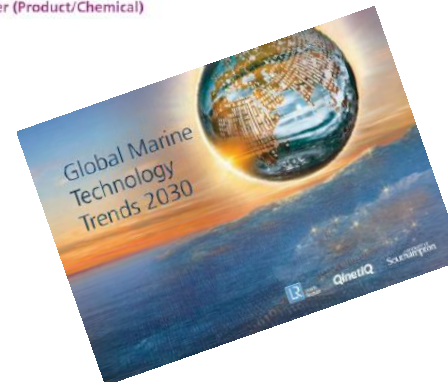
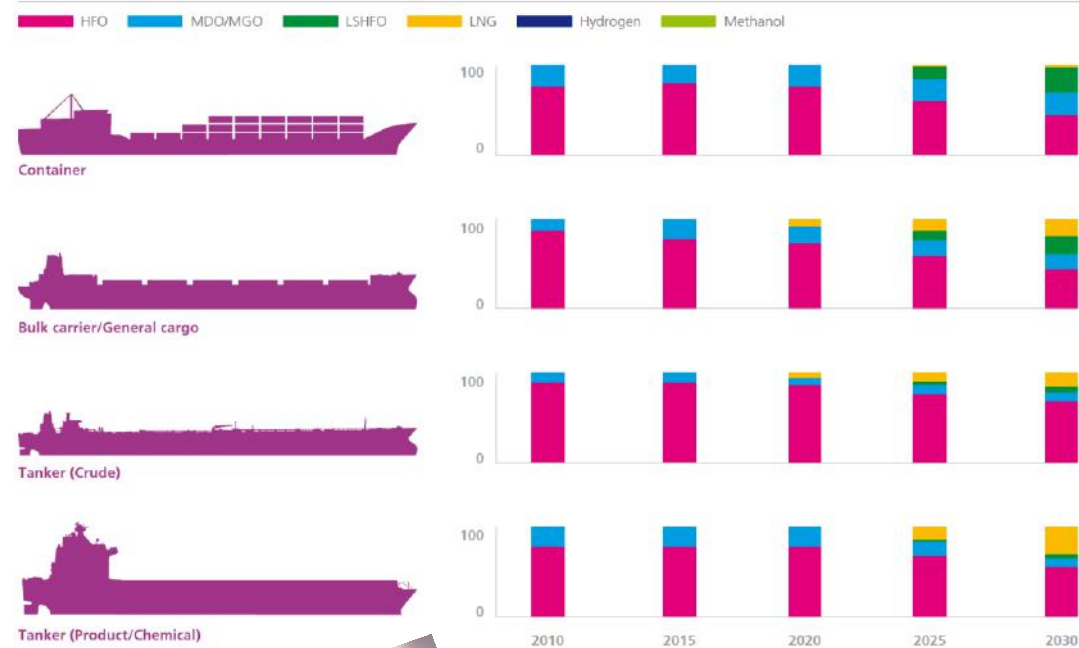


Lloyd's Register Fuel Trends 2030

LR has developed a set of studies to try to understand how the shipping world may evolve in the next years, in terms economy&trading, technology and fuel trends. Talking about fuels some interesting scenarios emerged:

- Even though HFO will remain the main fuel for shipping, the LNG quota is expected to reach **11%** by **2030**..
- ..but 11% in 2030 may be equivalent to abt. **20%** of **today** bunker volume

Fig. 15 Fuel mix for containership, bulk carrier/general cargo, tanker (crude) and tanker (product/chemical) fleet (%)
Source: LR / UCL



LR activities, from gas carriers to gas fuel ships & projects

Besides classification services, LR is actively participating in the technical evolution of gas fuelled ships engineering and rules:

- Developing **IMO IGC & IGF Code**
- Developing **IACS LNG bunkering** guidelines
- Member of the **Society for Gas as Marine Fuel** and participating to the development of the **SGMF bunkering guidelines**
- Participating to **EU projects Poseidon Med (1&2)**, with aim to develop a bunkering infrastructure and some gas fuelled lead vessels, including a feeder, in south-east Mediterranean, to solve the “chicken & egg” problem and boost the adoption of LNG as fuel.

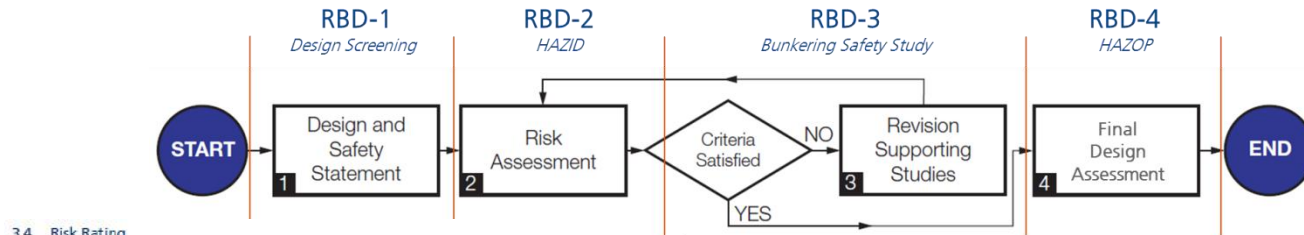
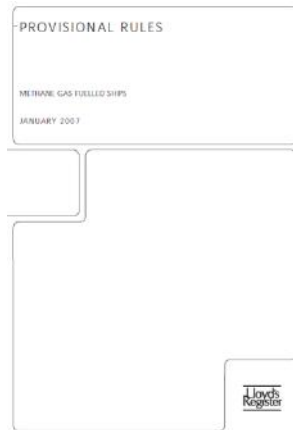


**POSEIDON
MED II**
LNG
BUNKERING
PROJECT



LNG & Low flash point fuels regulations evolution

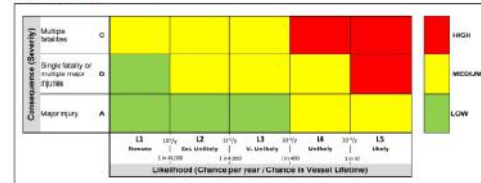
2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LR provisional rules for Methane ship		INTERIM GUIDELINES FOR NATURAL GAS-FUELLED SHIPS MSC.285(86)			LR Gas fuel Rules First release		ARBD ShipRight procedure First release	IGF code Resolution MSC.391(95) Adoption of final Draft	LR Gas fuel Rules Last update	IGF Code Entering into force



3.4 Risk Rating

Risks identified during the HAZID were rated in accordance with a risk matrix provided by LR Consulting as shown in the Figure below. This matrix is based on LR Consulting's experience in using and developing matrices on behalf of operators in the oil and gas industries. An assessment of risk before and after considering active safeguards was undertaken.

Figure 1: Risk Matrix



It should be noted that the risk ranking is only based on the assessment of risk to personnel and that low severity consequences that could result in minor injury have been excluded from the assessment. This approach helps to ensure that the study team only concentrate on significant risks; which is considered to be an appropriate approach for a HAZID of this type.



Working together
for a safer world

BC Ferries 145AEQ LNG Fuel System HAZID

Report for:
Lloyd's Register (Polska) Sp. z o.o

Rules and Regulations for the Classification of Natural Gas Fuelled Ships

January 2016



LR Risk Based Design

Class and Statutory Regulations require 'risk studies' to identify hazards and to assess and control risks and to show equivalence with SOLAS Alternative Designs and Arrangements.

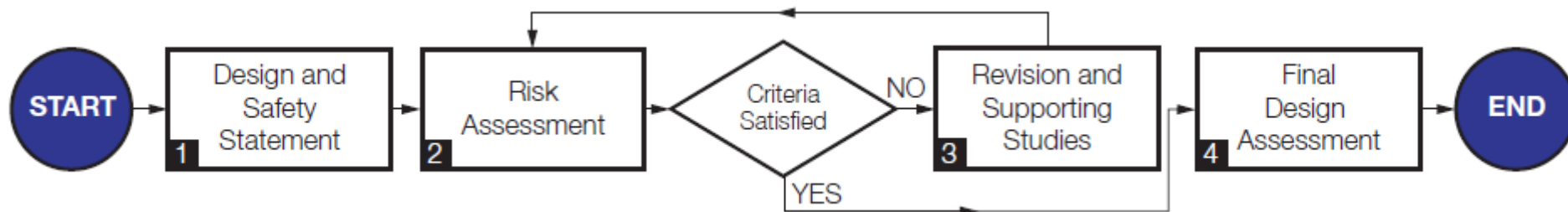
Risk Based studies are required for novel or complex designs for which prescriptive Rules and Regulations do not currently exist. To undertake consistently these risk studies, RBD process comprises the following stages:

Stage 1 – **Design screening**: benchmark against LR rules & IGF Code

Stage 2 – **HAZID** Risk Assessment.

Stage 3 – Revision and Supporting Studies (e.g. **Bunker Safety**).

Stage 4 – **HAZOP** Final Design Assessment.



RBD-1 Form Rev-02 GR(A) / RBD Stage 1

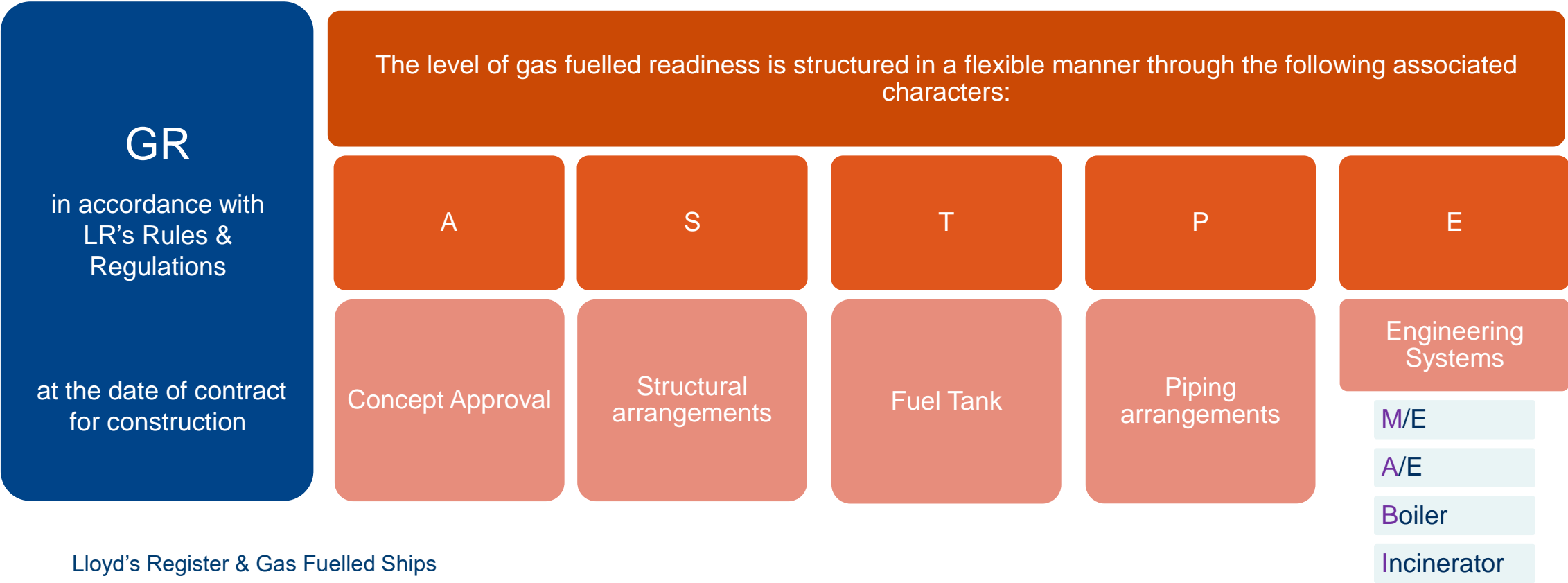
A. Fuel Tank – Protective Distance	Answer
1. At the summerload line, is the fuel tank(s) located at a distance greater than B/5 or 11.5 m (whichever is less) from the side of the ship? If the answer is NO or NA (not applicable), please provide further details here. GF 5.3.6 / IGF 5.3.3 The distance is measured from the ship's side shell plating to the primary barrier of the fuel tank (i.e. the barrier normally in contact with the fuel). For measurement purposes only, the primary barrier of the tank includes corrected plating that cannot be isolated, and the bowing valve along each plating (i.e. Tank Master Isolation Valve). Hence, if the distance measured is the plating or valve is less than that measured to the fuel tank then this distance is used in answer to this question. The meter is to be the greatest moulded breadth of the ship at or below the deepest draught (summer load line draught).	YES NO NA BS = 3.4 m Distance = 5.7 m
2. Other than at the summerload line, from the side of the ship, is the fuel tank(s) located at a distance greater than B/10 for a passenger ship or at a distance greater than 0.8 m for a cargo ship? If the answer is NO or NA (not applicable), please provide further details here. GF 5.3.6 / IGF 5.3.3 For a cargo ship, if the volume of a fuel tank(s) (Vt) is greater than 1,000 m³ then the following distance shall replace 0.8 m in the above question: = 0.75 + Vt x 0.24, 0.00 m, where 1,000 m³ < Vt < 6,000 m³; = 0.8 + Vt/75, 0.00 m, where 6,000 m³ < Vt < 30,000 m³; and = 2 m, where Vt > 30,000 m³. Vt corresponds to 100% of the gross design volume of an individual fuel tank at 20°C, including seams and appendages. Letter B is defined in Question 1. For guidance on measuring the distance see Question 1.	YES NO NA B/10 = 1.7 m

LR Gas Fuel Class Notations beyond LFPP(): Gas Ready

Gas Fuelled Readiness (GR) descriptive class notation

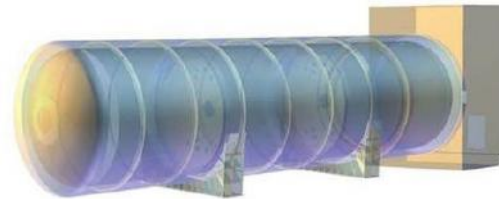
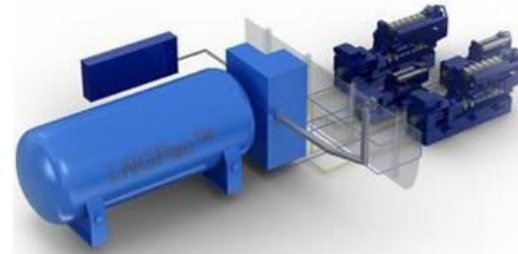
Introduces standard for clarity on levels of LNG fuelled preparedness

Provides recognition to investment decision



LNG Storage & Processing Basics on a GF ship

- Cryogenic tank holds LNG at abt -160°C
 - IMO Type C (pressure vessel, usually 3-10 barg)
 - IMO Type A/B (eg: prismatic, atmospheric pressure)
 - Membrane (MkIII / GTT96)
- Cold box or fuel preparation space contains piping, instruments, gas vaporizers, to bring gas-phase NG to engine at required P and T
- Bunker station provides connection for reloading the tank
- Dual fuel (oil/gas) or gas-only main engines or diesel generators
- Boilers can also be fitted with gas burners

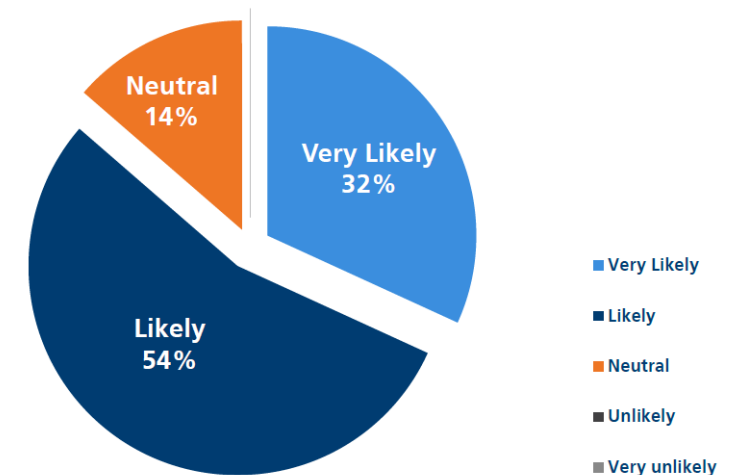
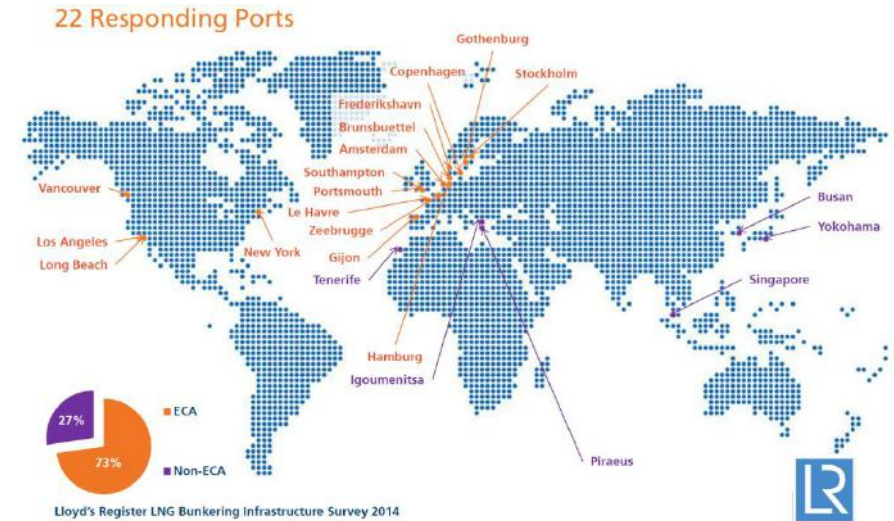


Is it going to happen?

According to LR Bunkering Infrastructure Survey 2014, carried out involving 22 major seaports in Europe, North America and Asia:

- 59% of them either have in place or have plan to provide LNG bunkering infrastructure for local shipping.
- 86% consider LNG as likely or very likely to be a viable bunker fuel for deep sea shipping
- 76% of them have a timeframe of 0 to 5 years for LNG bunkering operations to commence. For the others the time frame is no more than 10 years.

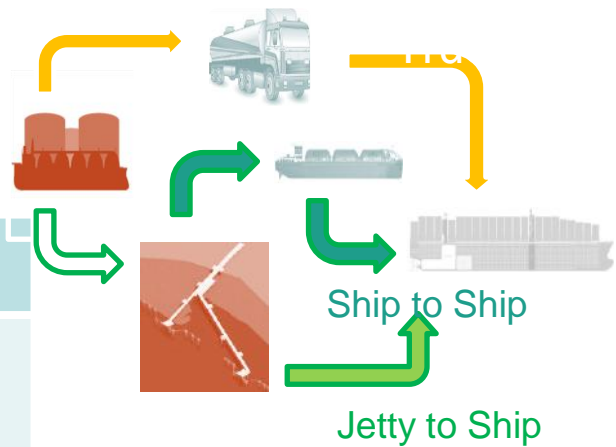
The answer therefore is yes, it is happening and there are good reasons to expect that it will eventually grow up quickly.



Bunkering highlights

Several options and technologies are available to bunker LNG fuel, each very different in terms of technology, size, investment cost, versatility, etc.

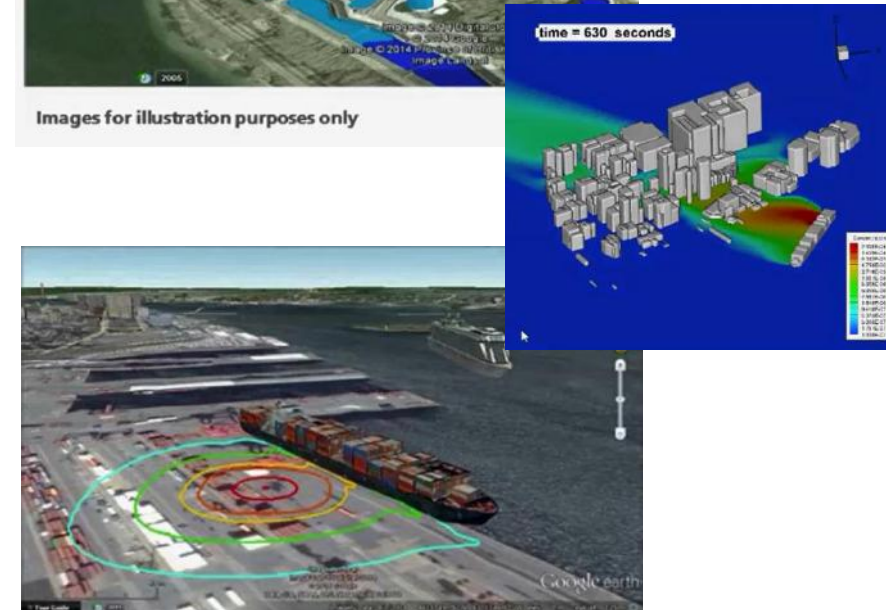
Technology	Pros	Cons
Ship-to-ship	Versatility Does not need facilities in the port Can be done at sea	Requires a dedicated ship (small scale LNG) Needs a LNG terminal somewhere
Shore-to-ship Fixed facility	Large quantity available Versatility in bunker technology Can be part of LNG terminal	Cost Risk management for ports Needs LNG shipping/routes for refilling
Shore-to-ship Trucks&Trailers	No investment Flexibility	Only small quantities Cost



Bunkering: Regulatory Framework & risk assessment

Bunkering is the connecting link between ship and shore regulations

	Ship	Port
Regulatory Framework	LR Rules for GF ships IMO IGF Code IACS Bunkering guidelines (under development)	National/local rules & laws ISO/TS 18683:2015
LR approach	<ul style="list-style-type: none">Supports & develops IACS bunkering guidelinesrisk assessment of the gas system which includes bunkering operationLR can provide technical support and expertise in the risk assessment of the ports, bunkering infrastructure, including CFD gas dispersion, explosion modelling	



LR Classed vessels overview

In recent years, LR has been working on many LNG fuelled ships projects, all over the world, most notably:

Ship/Project	Number	Type	Yard	Delivery
Greenstream&GreenRhine	2	IWW Tanker	Peters (NL)	2013
Viking Grace	1	RoRo-Pax	STX Turku (FI)	2013
F.A. Gauthier	1	RoRo-Pax	Fincantieri (IT)	2015
STQ 723,724	2	RoRo-Pax	Davie (CA)	2016
BC Ferries 615	3	RoRo-Pax	Remontowa (PL)	2016-17
NACKS 212,213	2	Vehicle carrier	NACKS (CN)	2016
Argonon	1	IWW Tanker	Trico (NL)	2011
Greenland	1(+2)	Cement carrier	Ferus Smit (NL)	2015
Arctech NB510	1	Icebreaker	Arctech Helsinki (FI)	2016

Let's have a quick look...

Fincantieri 6239 / F.A. Gauthier

- Delivered in 2015
- Owner STQ
- Loa 133.3m
- Service speed 20 kts
- Capacity: 180 vehicles, 800 passengers
- 4x5400 kw dual fuel (MGO/LNG) diesel generators
- 2x7000 kw electric main engines
- 2x280m³ LNG tanks with built-on cold box, 9% Ni steel, IMO Type C, double wall, MLI insulated.
- Route: Matane-Godbout-Comeau, St Lawrence river, Canada



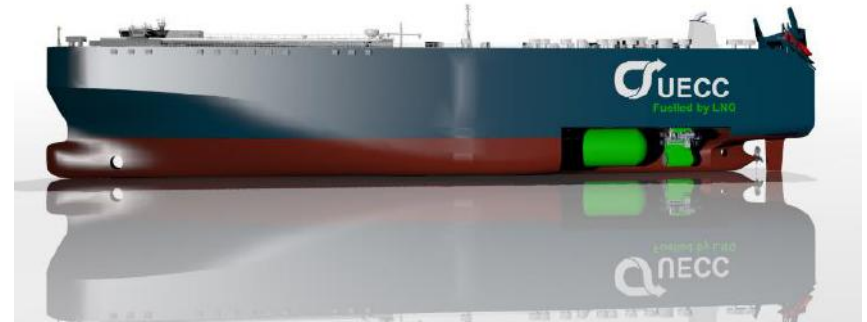
Arctech NB 510 “Polaris” Icebreaker

- Arctech Yard NB510
- Owner Finnish Transport Agency
- Delivered early 2016
- Polar class PC-4
- Loa 110m
- 2 x IMO Type C tanks, double wall design, stainless steel, total 800 m³
- Dual fuel (MGO/LNG) engines
- 3 Azimuth Thruster, total abt 19Mw
- Baltic sea routes



UECC / NACKS 212, 213 Car Carrier

- Delivery scheduled for 2016
- Owner: UECS, United European Car Carriers
- Loa 181
- 1A Super Ice Class
- Capacity: abt 3800 cars
- 2 Stroke 8S50 ME-C Dual Fuel engine
- 1000m³ IMO Type C single wall tank



Salish Orca, Eagle, Raven

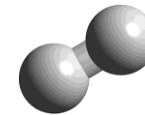
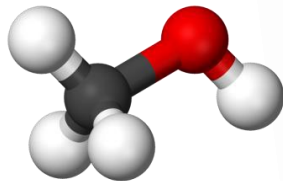
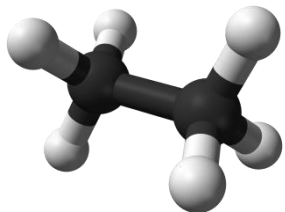
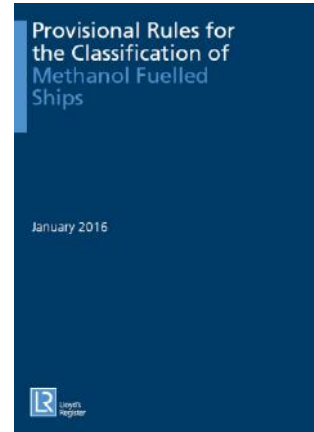
- Remontowa Yard 615/1,2,3 (sister vessels)
- Owner BC Ferries
- Delivery scheduled in 2016-17
- Loa 107.2m
- Cruise speed 15.5 kts
- Capacity: 150 vehicles, 584 passengers
- 3x1350kw Dual fuel (MGO/LNG) diesel generators
- 2x1400kw azimuth thrusters
- 130m³ LNG tank built-on side cold box, 304L steel, IMO Type C, double wall, vacuum perlite insulated.
- Routes: Vancouver area, Canada



Beyond LNG: Methanol, Hydrogen, Ethane, LPG,...

Lloyd's register is actively working and supporting projects related to other low flashpoint fuels, which may be a viable option..

- **Stena Germanica**: Conversion to **methanol** started with one engine in 2014, upgrading the existing **Sulzer ZAL40S**.
- **LR** involved in several methanol fuel related projects, such as **METHAPU**, **SPIRETH**, **MethaShip**, **LeanShip**, **proFLASH**.
- **VLEC** – Very Large Ethane Carrier are under development and construction. **LR** delivered **AiP** (Approval In Principle) to **Wartsila** for **50DF** engine design to burn ethane.
- Application of hydrogen fuel for fuel cell installation, stored in liquid form, is being proposed and investigated



LR Publications on these subjects

LR publishes some **free reports** which may be of interest..

- Gas Shipping Report (October 2015)
- Small Scale LNG Report (October 2015)
- What the IGF Code means for you (October 2015)
- What the IGC Code means for you (May 2015)
- LNG Bunkering Infrastructure Survey (2014)
- Global Marine Trends 2030
- Global Marine Technology Trends 2030
- Global Marine Fuel Trends 2030



Concluding...

- **LNG** is proving to be a viable fuel for shipping, particularly for ships engaged in routes within ECA (both **SECA** and **NECA**) areas
- **LR** is among the leading Class Societies in gas fuelled ships, with established **experience** and **know-how**, which traces its roots into the market-leading position in LNG carriers and benefits of extensive further investments and work.
- **Ferries** and **RoRo** vessels, well matching the points above, have been among the first GF ship projects, but **many other** types are in the business as well.
- **Regulatory framework**, both **LR** and **Statutory**, is in place to **manage** the **risks** arising from gas based propulsion, and it continues to be developed and refined.
- Other low flash point fuels, alternatives to LNG, are being developed or in their early adoption phase in some niches.

Questions?



Questions?

Thank you for the attention!

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