LNG Fuelled Vessels

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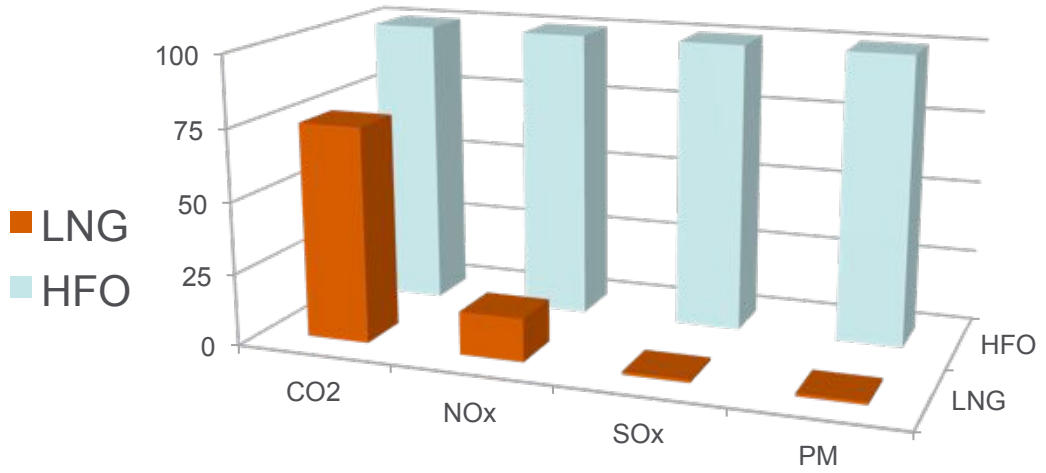
LNG as fuel for ships - Drivers

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 is somewhat detached from oil market

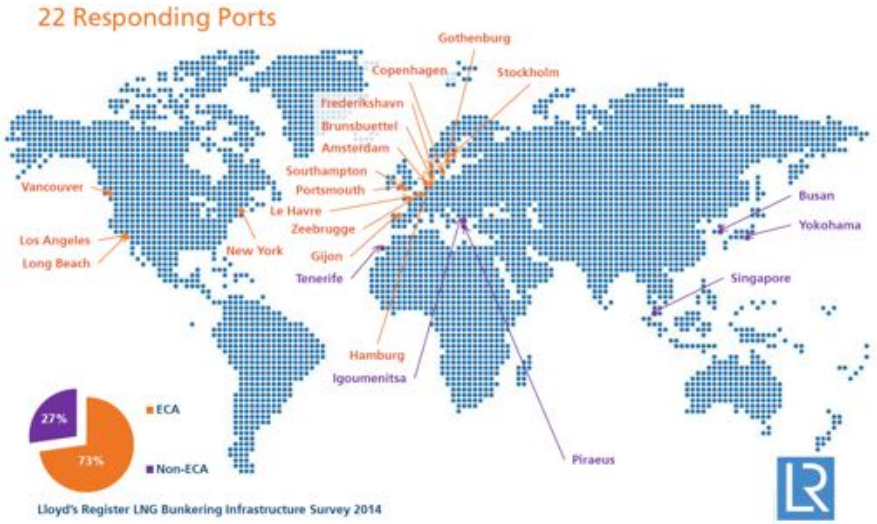


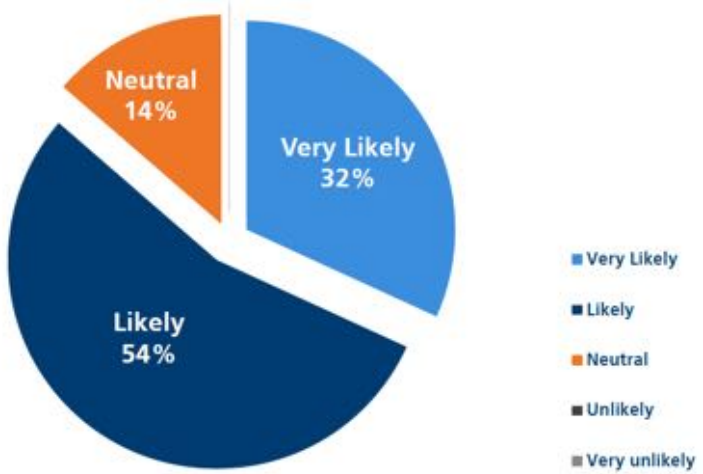
Is it going to happen?

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.

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





LNG Fuelled Ships: Why Ferries?

Routes mostly or wholly in SECA & NECA areas

No deep sea journeys

Limited LNG fuel consumption & frequent stops

LNG would meet both SOx & NOx requirements

Single bunkering facility/point can cover the whole route/s

Flexibility in bunkering technology and LNG fuel supply alternatives

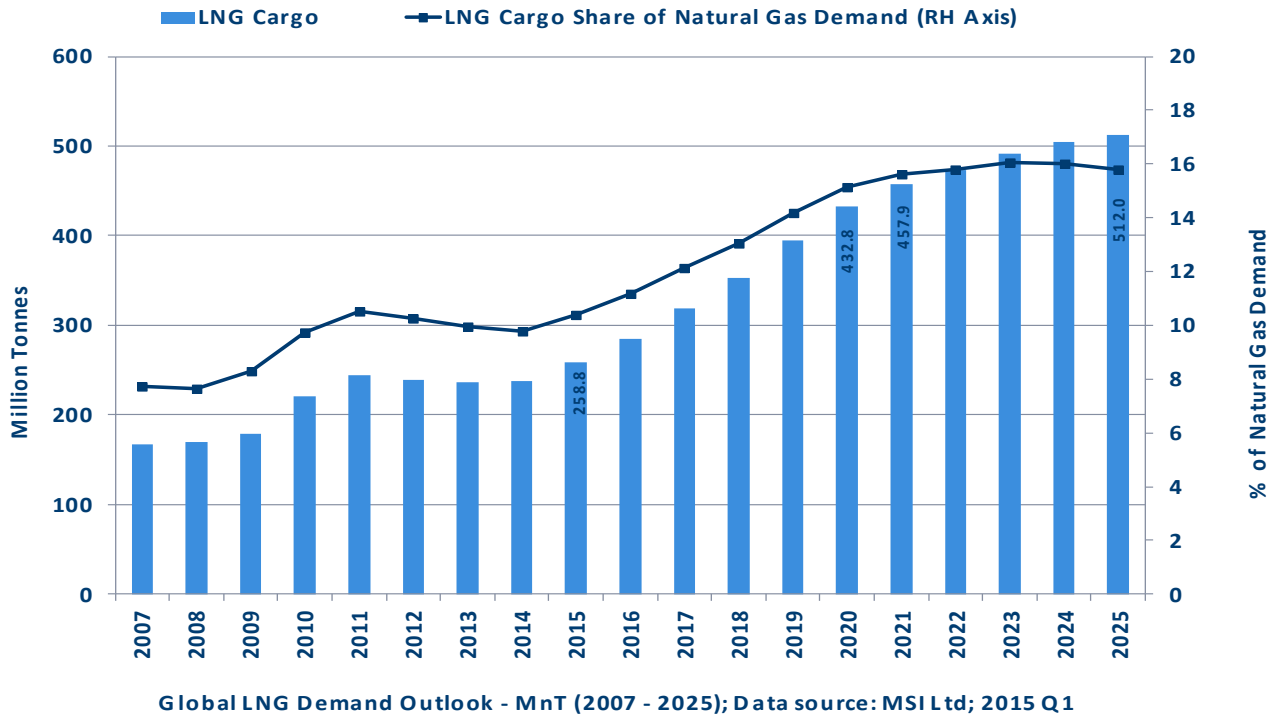
Strategic: Market responds to the academic studies

LNG role

Global Marine Fuel Trends 2030

LNG will reach up to 11% of the Deep Sea fuel mix by 2030

LNG cargo as a % of Natural Gas – 15.8% by 2025



Global LNG Demand Outlook - MnT (2007 - 2025); Data source: MSI Ltd; 2015 Q1

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LOW CARBON SHIPPING A SYSTEMS APPROACH

LNG Bunkering Solutions

Technology

Truck to Ship

Small quantities < 1,500m3

Preferred method 6,500m3

Ship to Ship

Possibilities

Jetty to Ship

CASE STUDY: Time to Bunker 6,500 cbm of LNG on Membrane Type Bunker Tanks

Time to transfer 6,500 cbm LNG: 6.5 hrs Time to complete LNG bunkering safely: 11.5 hrs

Pre-Bunkering Meeting
ESD Testing
Mooring / Securing Vessel
Establish Safety Zone

Cooldown of transfer system and receiving LNG tank

Draining LNG bunker pipes and transfer system including gas freeing and inerting of the bunker pipes

Main Assumptions:
LNG pump of 1,000 cbm/hr
BOG managed correctly

0 1hr 3 hrs 10.5 hrs

1.5hrs 9.5 hrs 11.5 hrs

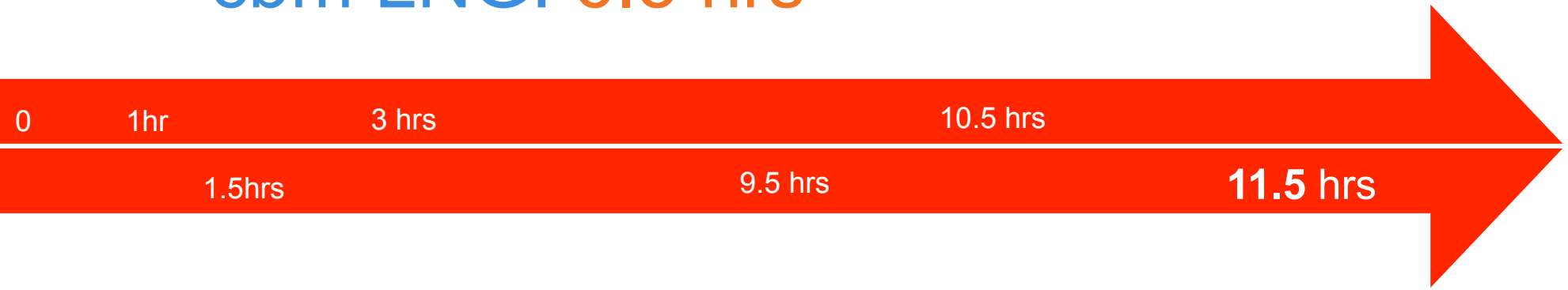
LNG Bunkering Connection
Nitrogen Purging of Flexible Hose / Loading Arm
"Gassing Up"

Full Bunkering Flow including Topping Up operation

Safe disconnection
LNG custody exercise
Unmooring and Post bunkering meeting

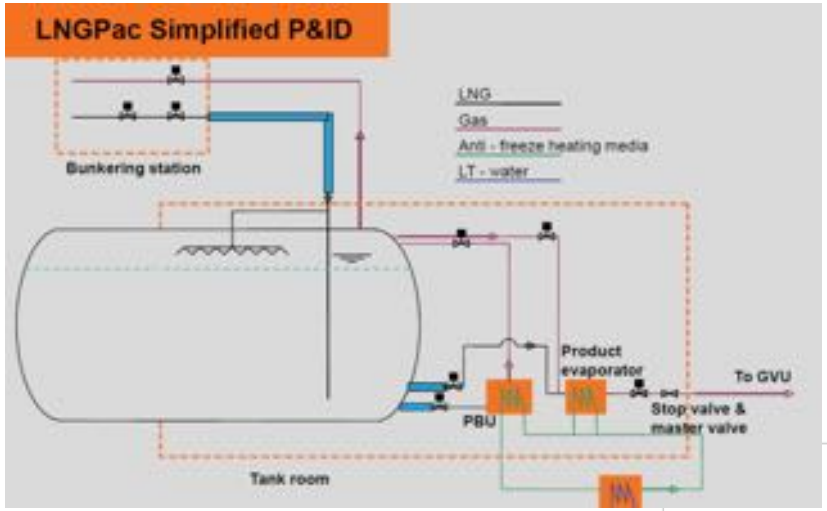
CASE STUDY: Time to Bunker 6,500 cbm of LNG on Membrane Type Tanks on a 18,000 TEU ULCS

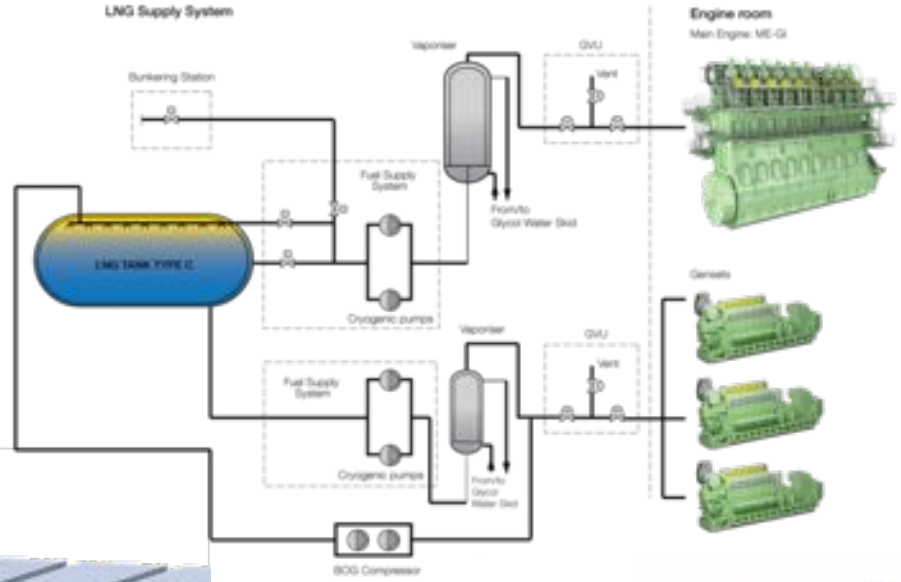
Time to transfer 6,500 cbm LNG: 6.5 hrs

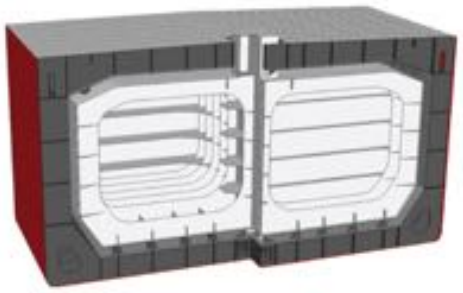


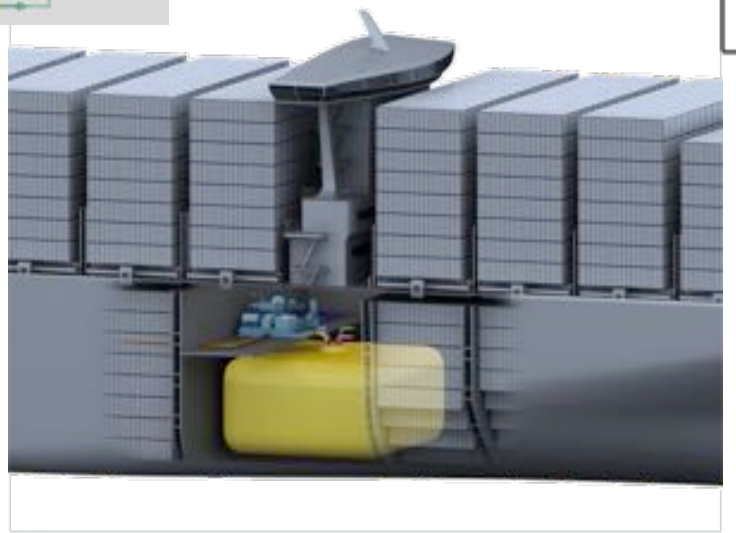
Time to complete LNG bunkering safely: 11.5 hrs

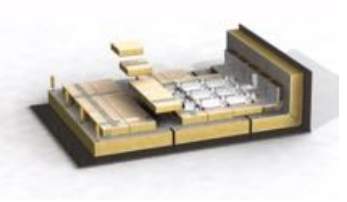
Technologies and Integration allow reliable LNG bunkering - Gas Fuelled Container Ships







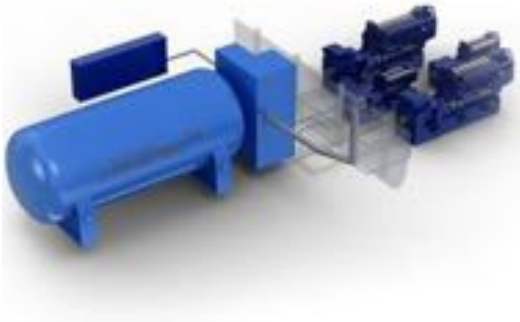


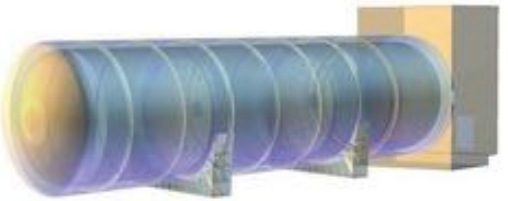


LNG Bunkering – Solutions for Ports

LNG Storage & Processing Basics

- 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



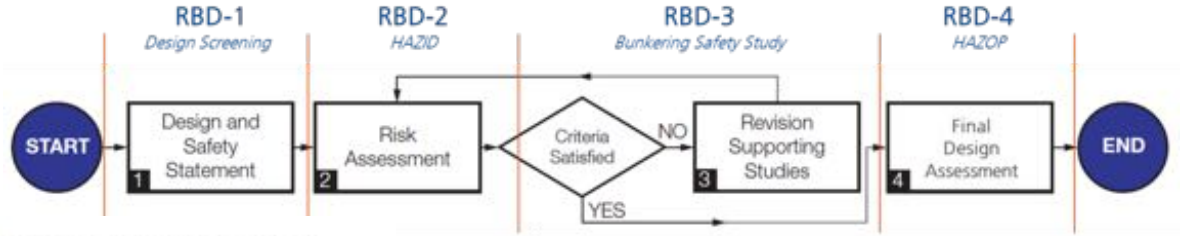


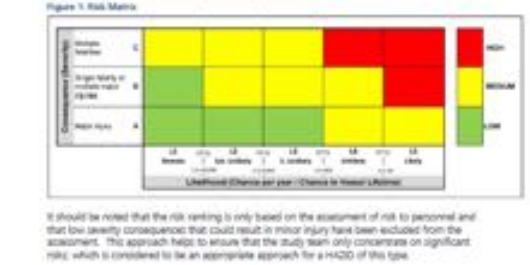
Main ship design highlights for LNG

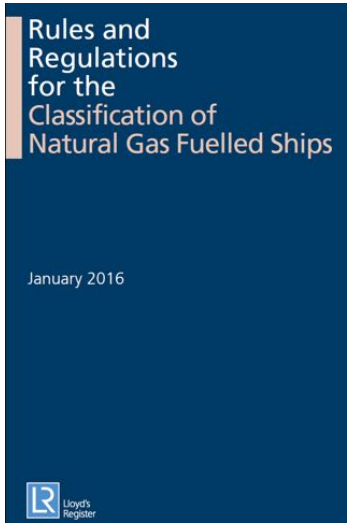
- LNG fuel tank shall be installed: volume is abt 1.5x to 2x equivalent fuel oil tank volume
- DF engines are almost identical in size & power to equivalent fuel oil engines
- Gas equipment in machinery space: limited footprint and no additional major hazards (provided that double-wall piping is installed)
- Dedicated tank hold space or gas tanks installed in open areas
- Extra ventilation ducts, vent mast, control system, bunker station
- Gas pipes: double pipe, relatively small diameter

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

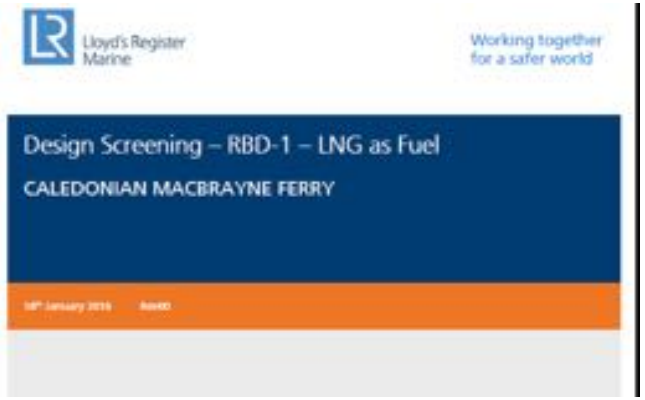






LR Approach

- “GF” Machiery notation: obtained by compliance with LR GF Rules
- Goal based design concept
- Some prescriptive requirements but due to the novelty and complexity of the application, Risk Based Design required
- Risk Based Design, or “RBD” required, 4 phases:
  1. Design screening: benchmark against LR rules & IGF Code
  2. HAZID Risk assessment
  3. Revisions and bunkering safety study
  4. HAZOP Final design assessment



Another Option: “GR” Gas ready notation. Design and in case partial installation is approved in advance for future completion of the installation and gas propulsion

LR Classed vessels overview

LR has been working on several LNG fuelled ferries/ro-pax projects, most notably:

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

and more are coming…

Viking Grace

- Delivered in 2013
- Loa 218m
- Service speed 22 kts
- Capacity: 2000+ meters for vehicles, 2800 passengers
- 4x7600 kw dual fuel (MGO/LNG) diesel generators
- 2x10500 kw electric main engines
- 2x200m3 LNG tanks with built-on cold box, Stainless steel, IMO Type C, double wall, vacuum perlite insulated.
- Routes: Baltic sea: Finland, Sweden, Estonia

Fincantieri 6239 / F.A. Gauthier

- Delivered in 2015
- 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

STQ 2nd and 3rd Vessels

- Davie Yard 723, 724 (sister vessels)
- Delivery scheduled in 2016
- Loa 92m
- Capacity: 115 vehicles, 432 passengers
- Dual fuel (MGO/LNG) engines
- 110m3 LNG tank built-on cold box, 304L steel, IMO Type C, double wall, MLI insulated.
- Cross St Lawrence river, Canada

Remontowa / BC Ferries projects

- Remontowa Yard 615/1,2,3 (sister vessels)
- Delivery scheduled in 2016-17
- Loa 107.2m
- Cruse 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

Conclusions

- LNG is a viable fuel for shipping
- Has established as an alternative to scrubbers/SCR to sail in ECA areas
- Thanks to their operating profile and routes, ferries & RoRo vessels are ideal ships to take advantage of LNG as fuel
- LR has established experience and know-how on such vessels
- Regulatory framework is in place to manage the risks arising from gas based propulsion

Questions?

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Thank you for the attention!

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