LNG Shipping Fuel – The Future

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LNG - The fuel for the future

– A paradigm may take place
  • LNG may substitute heavy fuel oil and marine gas oil

– Challenges
  • Gas / LNG fuel safety culture to be further developed
  • The supply chain and availability of bunkering station in ports
Methane / LNG as Shipping Fuel

The future, three important drivers

• A clean fuel
  – Can meet the IMO tier 3 requirements on emissions
• Economical
  – LNG has the potential to be economical competitive to heavy fuel oil (HFO)
• Quantity
  – The predicted amount of natural gas is huge. May last for the next 1000 years if Gas Hydrates are included
LNG as Shipping Fuel

Tariffs 2011 --- 2012 USD/ton

- Current HFO
- Current MGO
- LNG Zeebrugge

Tariffs 2011 --- 2012 USD/ton
History of Natural Gas - Methane

• China first to use Methane
  – 2500 years ago the Chinese started to hardnerness (pipe) the natural gas for the purpose of heating water to obtain salt*

• Used in England since 1659
  – Did not, on world base, replace coal gas before 1945

• First used in USA in 1816
  – In gas lamps to illuminate the streets of Baltimore

* A. Demirbas 2010
First practical gas engine 1860

- Prior designs were patented as early as 1807
History of LNG

LNG dates back to 1825, when British chemist and physicist Michael Faraday experimented with liquefying of gases.

German engineer Karl van Linde built the first practical refrigerator machine in 1873.
LNG as base for fuel – Clean fuel, but a Gas

- LNG 90/9 Methane/Ethane Cooled to -162°C

- Natural gas
  - Energy 13.69 kWh/kg
  - Density 0.78 kg/Nm³
  - Ignitable blend 5 to 15% volume in air
  - Igniting energy 0.25 mJoule (diesel 20 mJoule)
  - Auto igniting at 580°C (diesel 260°C)
Large Scale LNG Shipping: 50 years of operation

• Started in 1963 from Algeria
50 year Safety record on Shipping of LNG - Good

180 Ship-LNG accidents;
- **1 fatality** –valve material
- 5 gas fires
- 2 fires engine/insulation
- 2 explosion engine room
- 1 explosion cargo compressor
- 21 spills w/cracks
- 24 collisions no spill
- 8 ground-/stranding no spill
- 11 barrier failure no spill
- 7 mooring failure no spill
- 9 cargo pumps no accident
- 89 Engine/shaft/rudder
and other ship systems.
Safety record on Shipping of LNG

- Fatal accident with LNG
  - 1977 LNG Delta at loading terminal. Aluminium valve failure on contact with LNG. Wrong aluminium alloy on replacement valve

- The Cryogenic danger – Special materials
Norway – Leading in use of LNG in Shipping

- Research on modern gas engines since 1980 (offshore O&G)
- First ferry in 2000
- Good LNG supply
- 34 ships in operation
  - 92% of WWF LNG IGF ships
- Notable international interest
Positive proof of global warming.

Incentives in Norway – NOx -tax

- Environmental effects is the main driver, implemented by:
  - Political decisions on public transport (ferries)
  - Private agreements - green policy (supply ships)
  - Emission tax on NOx ~ NOK 16,7 pr. kg, or;
  - Owners can join the private NOx found and only pay NOK 4,00 pr. kg and be able to re-allocate founds when investing in low NOx technology ie. New diesel engines, LNG engines, Selective catalytic reduction systems (SCR) etc.
Operational experience with LNG in Norway

Viking Energy - Eidesvik

- Gas mode in 97% of total energy production time.
- Diesel mode during LNG refueling of LNG, under maintenance operations or if triggered by alarms.
- Viking Energy: 9 yrs. without one hour off-hire caused by the gas system.
Norwegian experience on emission

- **Particles**
  - MDO - 1% S: 0.25 g/kWh
  - LNG: 0.05 g/kWh

- **SOx**
  - MDO - 1% S: 6 g/kWh
  - LNG: 0.1 g/kWh

- **CO2**
  - MDO - 1% S: 600 g/kWh
  - LNG: 500 g/kWh

- **NOx**
  - MDO - 1% S: 10 g/kWh
  - LNG: 1 g/kWh

Together for improved safety at sea in a clean environment

LNG fuel - Norwegian exp. MarTech LNG Baltic Sea Region
Environment driven focus on use of LNG in shipping

Today in Norway
- Local ferry trade
- Regional bulk cargo trade
- Offshore Supply vessels North Sea
- Coast Guard vessels

To come
- Short Sea – Europe trade
- WW – trade into other ECA
- WW – trade in general
## Summer 2013 - 34 LNG fuelled ships flying NIS/NOR flag

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<th>Year</th>
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This was up to July 2013 the World’s largest LNG-only Ferry, in operation in December 2011. 130x19,2m, 242 cars or 22 trailers + cars on lower deck. NOX red 90% compared to diesel.
MS Tidekongen LNG Powered passenger ferry, July 2009. 50x12,1m 628 pax. (1of 3 in OSLO)
11 New LNG ships to NOR/NIS flag

2013 Kleven no: 347 PSV
2013 Car/passenger ferry
2013 Car/passenger ferry
2013 TUG
2014 ROPAX
2014 TUG

More new builds expected on the list in 2013
Supply of LNG – liquefaction facilities in Norway

- Kolsnes LNG plant
- Karmøy LNG plant
- Risvika LNG plant
- Melkøya LNG export plant
  (first large export plant in Europe)
Bunkering of LNG

- From shore based tank farms, at LNG plants
- From shore based tank farms, refilled by Costal Gas tanker and or trailer
- From trailers on quay / ferry terminal (most common method today)
  - Only one loading arm used, most common is steel braided flexible stainless steel hoses
LØDINGEN
MOSKENES
BODØ
Barents Naturgass
Terminaler 150 – 250 m³ (ferdig 2012)

ÅLESUND,
Naturgass Møre
Terminal 1366 m³

ÅGOTNES (CCB),
Gasnor
Terminal 450 m³

HALHJEM,
Gasnor
Terminal 1000 m³

RISAVIKA (Stavanger)
Skangass
Fabrikk/Terminal 30 000 m³

Fredrikstad
Skangass
Terminal

HAMMERFEST,
Barents Naturgass
Bunkringsportal 100 m³
Safety record for LNG fuel system (NO)

• No reported or recorded accidents

• One heavy crash with quay due to failure in maneuvering system – No problem with the LNG tank or gas system (Glutra)
Accidents in conjunction with bunkering (NO)

- One problem with valve system on semitrailer. Very small spill onshore.
- One leakage on hose and a small spill of LNG onshore (1 liter)
- No other accident recorded, However

- A LNG accident resulting in need to rebuild steel has happened at Yard before delivery
LNG out-pumping from bunker station – Yard accident

• The result from the exposure of LNG (-160 C), from the bunker pipeline to the hull, was rapidly cooling of the steel followed by several large crack in deck plates, gutter, beams, stiffeners and shell plates.
Safety for LNG trailers in Norway

A history of 12 years operation with more than 60,000 loading and unloading operations to ships, industry and local feeder tank farms

- One leakage on hose during loading of truck and a small spill of LNG onshore (2 litre)
- One trailer that run out of the road in 2002. No LNG spill and trailer recovered
- A second trailer run out of the road in 2010. No LNG spill and trailer recovered
Norwegian regulations on LNG fuelled ships

• Regulation in force

• Some of the strict rules are already lifted
  Today use of IMO Resolution MSC 285(86) Interim Guideline on safety for natural gas-fuelled engine installations in ships, accepted on passenger ships.
Norwegian Experience in LNG as Shipping fuel

• Status Sept. 2013
  - NMA concludes that the safety of the LNG fuelled ships is good, but notes that most LNG shipping operations to day are focused with dedicated bunkering arrangement.

  - A general increase LNG shipping activity may require further development of safety culture and standard solutions which can be utilized by “any” LNG ship.
Ensuring Safe Bunkering of LNG

The important question now, especially for ROPAX:

- Is it feasible to have passengers on board and to load or unload passengers or cargo whilst re-fuelling?

- Yes, if safe bunkering systems and the right safety measures are established, used, controlled and maintained
Maritime regulations on bunkering of LNG in Norway

Passenger ships, RORO ships and Cargo ships

- Written specific procedure to be established for each method of bunkering to be utilized (Also to be in acc. to the regulations from Directorate for Civil Protection and Emergency Planning - DSB (http://www.dsb.no/no/toppmeny/English/))
Shore based regulations on LNG bunkering of ships

• Bunkering from shore to ship is regulated by the:
  – The Directorate for Civil Protection and Emergency Planning – DSB

• For the time being it is not allowed to have passengers onboard or load and unload cargo whilst re-fuelling of ferries’

  – Revised regulations soon to be proposed. Bunkering may be done with passengers onboard if safety is taken care of.
What may Safe LNG Bunkering Systems be?

• Generic safety level equal to MDO systems
  – Standard connections to ship LNG bunkering station
  – Mechanic flange coupling – no manual bolting
  – Defined standard flow rates
  – Cold Gas return piping (no planned venting allowed)
  – No spill due to single failure – double barriers
  – No spill when decoupling, whatever reason (Dry break)
  – Valve- and pipe design to allow sudden shut down (5 sec)
  – All areas possible exposed to LNG to be of cryogenic safe materials (also if first barrier fails)
What may Safe LNG Bunkering Systems be?

- Drip trays to be fitted
- Gas and Nitrogen purging system
- ESD control system between shore and ship systems to be linked
- Fail Safe Systems, not dependable on operators
- Safety zone for any destructive forces / ignition source
- Risk assessment on the significant bunkering solution
- Safety work permit, before any bunkering operation
- Plan for emergency preparedness
- Plan for change in safety alert level and safe evacuation
- Standard ship bunkering regulation (EU. WW)
Cooperation for new regulations

• Common risk assessment of LNG bunkering operations both from shore and between ships

• Several meetinging between shore authorities and maritime authorities
Resultat isorisk

Beregning av bunkring fra en fast tank på land med slangekran til skipet.

Beregning av bunkring fra en tankbil på land med slanger til en rigg og videre med slangekran til skipet.

<table>
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<tr>
<th>Lokal (stedbundet) risiko</th>
<th>10⁻⁷ pr. år</th>
<th>10⁻⁸ pr. år</th>
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International regulations – the IGF code

• 2004 Proposal from Norway to develop gas code

• 2009 Interim guidelines adopted in June 2009 Resolution MSC.285(86)

• 2013 Draft International Code of Safety for ships using gases or other low flashpoint fuels – to be ready for adoption by MSC in 2014 and in force 2015/2016

• Basic functional requirement
  The safety, reliability and dependability to be equivalent with new and comparable conventional oil-fuelled main and auxiliary machinery
Safe use of LNG – Important work in ISO

ISO TC 67/WG 10 (Guidelines for systems and installations for supply of LNG as fuel to ships)

• Minimum requirement for the procedures, training and equipment necessary to ensure the safe LNG bunkering operations of gas fuelled ships from; bunkering vessels and barges, and onshore installations, either from fixed storage tanks or LNG trucks.
Norwegian regulations on LNG fuelled ships

- If questions regarding how to build and or operate vessel under the Norwegian flag:

  Look for info at: www.sdir.no or
  Send an e-mail: post@sdir.no or
  Call us on +47 52745000

  You are welcome!
As we safely dive into a cleaner future:

Thanks for Your Attention!
Training for crew on gas fuelled vessel (IGF- Code ships)

Lasse Karlsen
Training requirements - maintenance

- Personnel that shall perform maintenance on electrical installations in explosion hazardous spaces should be qualified pursuant to IEC 60079-17
Training requirements - levels

• **Level A: All crew**
  - General basic training on gas-safety, operation and maintenance.

• **Level B: Deck officers (+ others with gas/LNG duties)**
  - Special training for operation of gas-related equipment i.e bunkering.

• **Level C: Engineer officers**
  - Special training for operation of gas-related equipment
  - i.e gas-system and engine particulars.
Training course assessment

• Passenger ships acc. to Norwegian regulations:
  – To be approved by NMA

• Pax- and cargo ships acc. To MSC.285(86) guidelines:
  – Owner/company responsibility
Required reading, course level A (all crew)

• Basic theoretical training
  – Basic knowledge of gas
  – Thermodynamic properties of natural gas
  – Liquid Cryogenic gases and phase transition
  – Explosion levels UEL/LEL
  – Control and monitoring of gas, barriers
  – Principe of RISK-assessment
  – Probability- and consequence reduction
  – Simplified analysis of risks
  – Risk events; leakage, explosion and fires
  – Emergency preparedness
  – TQM – total quality management
  – Safe work analyses, hot and cold work permit
  – Regulations
Required practice, course level A (all crew)

• Basic practical training:
  – Control of gas fires
  – Flash point and auto ignition temperatures
  – Different extinguishant - benefits/disadvantages
  – Fire in gas and liquids
  – Ignition energy and combustible mixture UEL/LEL
  – Personal protective equipment gas/LNG
  – Gas detection with test gas
  – ESD of gas system and engine
  – EX areas, entering procedures and equipment
  – Set of exercises
Required reading, course level B (Deck officers +)

- Additional theoretical training
  - Gas/LNG system review
  - Power supply system
  - Monitoring and supervision
  - Interlocked and automatic operation
  - Bunkering
  - Redundant systems
  - Gas fire hazards and damage
  - Shutdown gas engines
  - Shutdown gas system
  - Set of exercises

18.09.2013

LNG fuel - Norwegian exp. MarTech LNG
Baltic Sea Region
Required reading course level C (Eng. officers)

- Additional theoretical training
  - Purging and gas-freeing
  - Quality of gas / Methane number
  - Heat value of Methane
  - Ignition failure/knocking
  - Maintenance of gas/LNG system
  - EX equipment
  - Electrical installations in could box and engine room
  - Gas pipe system/ double wall piping
  - LNG evaporator
  - Principle of gas engines
  - Shutdown of gas engine/gas supply

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Training requirements; time-frame

• Level A: All crew
  – General basic training on gas-safety, operation and maintenance takes 1.5 to 2.5 days

• Level B: Deck officers (+ others with gas/LNG duties)
  – Special training for operation of gas-related equipment i.e. bunkering requires 0.5 day in addition

• Level C: Engineer officers
  – Special training for operation of gas-related equipment
  – i.e. gas-system and engine particulars requires 0.5 day in addition
Proposed regulations on LNG fuelled ships

• Training requirements for the ship crew
  – Level 1 General for all crew
  – Level 2 Deck officer's
    Engine officer’s