LNG as fuel for ship propulsion

INTERTANKO / INTERCARGO - London

Claus Winter Graugaard - Deputy Head of Maritime Services
16 November 2010
LNG as fuel – Enablers for industry

1. REGULATION
2. ENVIRONMENTAL DRIVERS
3. WHAT IS LNG
4. FINANCIAL DRIVERS
5. INFRASTRUCTURE
6. RULES & STANDARDS
7. TECHNOLOGY & INNOVATION
IMO Emission Control Areas, ECA

The Baltic Sea and North Sea are regulated as ECAs with limitations on sulphur emissions (Previously termed SECA).


<4.5% Now
<1.0% Aug '12
<0.10% January '15

<1.5% pre July '10
<1.0% Now
<0.10% January '15
Not only ECAs – also EU regulations in EU ports!

**ECA (Emission Control Area) requirements:**

- **Maximum level of sulphur in fuel, new and sailing ships:**
  - 1,0% by 1st July 2010
  - 0,10% by 1st January 2015 (or equivalent measure)

- **Nitrogen emission for newbuildings:**
  - 80% reduction in NOx emissions from 1st January 2016

**EU fuel requirements today:**

- 0,1% sulphur in ports and inland waterways (or equivalent measure)
LNG is supreme for SOx and NOx removal

Applies for a typical general cargo ship
3300 kW installed

* Low sulphur fuel contains maximum 0.1% sulphur
** Conventional fuel as per 1 July 2010, containing maximum 1% sulphur
You have only 3 options for SOx removal!

1. LNG as fuel
2. Scrubbers for exhaust gas purification
3. Low sulphur fuel

...or fleet redeployment, i.e. give up trading in ECAs!
What is Natural Gas / LNG / CNG?

**Natural Gas**

- **Liquefied Natural Gas**
  - Cryogenic Liquid
  - 0.25 Bar
  - -163°C
  - 0.42 t/m³

- **Pipeline Natural Gas**
  - Pressurized Gas
  - 100 - 150 Bar
  - 0°C to 20°C
  - 0.1 - 0.2 t/m³

- **Compressed Natural Gas**
  - Pressurized Gas
  - 100 - 275 Bar
  - 45°C to -30°C
  - 0.2 - 0.25 t/m³

**Volume ratio 1/600!**
LNG block flow diagram

Source: Suhkri, T., Hydrocarbon Engineering, February 2004
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Competence / Training

LNG as fuel is not complicated. Understanding the specialities of LNG and the necessary procedures to be followed, particularly those different from oil, is essential. The most important are

- the low temperature of LNG, -163 centigrades
- methane (CH4) has lower specific gravity than air, i.e. possible leaking gas will ascend (LPG is opposite)
- risk of explosion (5 – 15 % methane mixed with air)

Procedures for operation, bunkering, gas freeing and emergency situations must be established in each case, based on understanding above characteristics
Financial Drivers and Infrastructure
Growing predicted price disparity oil /gas

Current LNG fuel sales price in Norway

Increasing distillate prices (demand/production)?

LNG fuel price development?

Source: EIA
Recent development of gas prices

![Natural Gas Spot Prices Graph](image_url)

- **Henry Hub**
- **Zeebrugge**

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LNG pricing

- 4 USD/mmbtu
- 7-8 USD/mmbtu
- 10-11 USD/mmbtu
Estimated additional costs: 1000 – 2000 €/kW installed

Rough estimates for additional CAPEX for LNG tanks, distribution, engine, larger vessel:

![Graph showing added cost of investment for LNG propulsion vs installed power]
Economical benefits

- Conversion of exiting ro/ro passenger vessel and 17 years remaining operation.
- LNG at 12$/mmbtu = 570$/ton and 2.4% inflation vs. MGO at 700 $/ton

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LNG bunkering station and LNG terminals

Maritime LNG providers:

Gasnor (dominates N Europe)
Nordic LNG (Norway)
Skagerak Energi (Norway)
Barents LNG (Norway)
Gassum OY (Finland)
Clean Energy (USA)
Excelerate Energy (USA)

+ newcomers!
Proposed new LNG distribution terminals
European LNG terminals
Use existing bunkering system also for LNG fuelling!

- More LNG suppliers are now entering the market…
  - Expect changes in LNG price to end user
  - Expect a denser fuel bunkering grid

- Import of LNG from international markets has clear economic advantages compared to local small-scale LNG liquefaction.

- Expect higher price for alternatives to LNG (i.e LS distillates) in ECA zones
Small scale LNG distribution in Norway
The proper way of doing small scale LNG
Significant interest for ”small scale LNG” around the world
Technology and innovation
Technology is approved and available

- Many manufactures are offering LNG fuelled engines:
  - Wärtsilä
  - Rolls-Royce
  - MAN Diesel
  - Mitsubishi

- Main challenges are the loss of cargo space due to cylindrical LNG storage tank, and a slight methane slip from engine when running on low load (continuous improvements)

- Development is ongoing to shift from cylindrical (volume consuming) to hull integrated tanks

- Fuel cells on LNG for ship propulsion are under development (FellowShip)
International and national rules and guidelines

IMO - IGC Code
Rules for the bunker boat, which is a small LNG carrier

IMO – interim guidelines
Safety for gas fuelled engine installations in ships (MSC.285(86))

Based on DNV rules

IMO - IGF Code
Rules for the receiving ship, the ship using LNG as fuel

SIGGTO
Guidelines for LNG transfer

OCIMF
Guidelines for Oil transfer, ship to ship oil bunker procedures

Port regulations
USCG, local authorities

Onshore regulations
EU, NFPA, FERC....

Additional Class notation:
Gas Fuelled
Inherently gas safe machinery space

Double piping all the way into the engine room (similar to IGC code)

"Inherently gas safe engine room"

All gas pipes in engine room are enclosed in a double pipe/duct that can withstand the pressure build up during pipe rupture.

- Double pipe/duct to be pressurised and filled with inert gas or ventilated and with gas detection
- The room around is an ordinary machinery space without special requirements
- The concept is mandatory for high pressure piping (>10 bar), but can also be used with low pressure installations
ESD protected machinery space

LNG as fuel for ship propulsion

Dual fuel engines with Gas-electric propulsion

- Ventilation: 30 air changes/hr
- Gas detection
- Automatic shut down of gas supply and disconnection of electrical equipment
- Excess flow shut down

Typical LNG consumption: 10-15 t/d.
Typical tank capacity: 100-200 t LNG
More than 20 LNG fuelled ships identified worldwide:

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<th>Year</th>
<th>Type of vessel</th>
<th>Vessel name</th>
<th>Owner</th>
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10 years of experience with LNG fuelled ships in Norway

DNV has proven rules for LNG since 2001

The world’s ships on LNG fuel built to DNV class!*

*LNG tankers excluded
Fleet development

Development of LNG fuelled ships
Existing fleet and confirmed orderbook

Other class - New
Other class - Existing
DNV - New
DNV - Existing

0 2 4 6 8 10
Fleet development

Development of LNG fuelled ships
Existing and orderbook

Number of new LNG fuelled ships
0 1 2 3 4 5 6 7 8 9 10

Total number of LNG fuelled ships
0 10 20 30 40

- Ships delivered
- Cumulative
5 more ferries delivered from 2007

MF Bergensfjord

- Builder: Aker yards, Romania & Norway
- Capacity: 587 pax / 212 cars
- Trade: 35 voyages / day
- Bunker station: Halljem
- Speed: 3 x 21 knots, (2 x 17 knots)
- Engine: Rolls Royce Marine, Bergen KV-GE, 2x16 cyl, 3530kW, (2x12cyl, 2650kW)

35 port calls per day = 12 775 per year
Costal LNG Carrier: ”Pioneer Knutsen”

- delivered 2004, 1100 m³ cargo carrying capacity
- 2 x engines for gas fuel only + 2 diesel engines, - diesel electric propulsion
- 2 pods for main propulsion + bow thruster
- redundant propulsion
On order:
Coastal oil bunker vessel – with new type LNG tanks!

“A-type” under approval…

✓ Fuel from cargo boil-off
✓ Low cost propulsion

Short engine room

Design: Rolls Royce Merchant Solutions
Conceptual: Energy efficient designs, including LNG fuel.

- Product carrier (15,000 tdw) with gas fuelled engines
- LNG fuel tanks on deck
- Fuel capacity: 22 days of operation

Source: Stena
Viking Lady: NOx reduction equals taking 22,000 cars off the street!

Viking Lady’s reduction in NOx emissions compared to diesel operation

LNG fuel

Diesel fuel
Fuel cells with LNG: The FellowSHIP project

"A Battery – without need for recharging"

Silent
Clean
Effective

- 340 kW fuel cell was delivered to OSV Viking Lady March 2009.
- Replaces one Auxiliary engine
New design: LNG fuelled terminal tug
Common beliefs and reality (1)

☑ “I’d rather run my vessel on low sulphur fuel or install scrubbers. Then I will avoid the LNG investment and still comply with ECA regulations”
- Looking at the future availability and price of low sulphur fuels, and at abatement technology for purifying heavy fuel oil emissions, LNG is a good solution

☑ “LNG technology reduces the available cargo space and thus suits only large vessels”
- Development is ongoing to shift from cylindrical (volume consuming) to hull integrated tanks which will reduce space need and cost.

☑ “I have heard that the LNG fuel market is dominated by a very few suppliers”
- Still true – but looking into the future the price for LNG to end user will be further harmonized with the open market LNG price (Henry Hub, NYMEX)
Common beliefs and reality (2)

☑ “The vessel is forced to bunker at dedicated terminals”
   - There are currently 12 bunkering stations in Norway, new stations planned in Sweden etc. Solutions for ship to ship bunkering is under way.

☑ “I am concerned about the vessel’s operational flexibility when using LNG as fuel”
   - Per date there are admittedly some limitations regarding bunkering stations, frequency of bunkering and second hand value – but this may change soon!

☑ “LNG propulsion is not a financially sound investment”
   - DNV have carried out a number of studies on different economic scenarios and demonstrated that LNG is a viable solution for many ship owners
Conclusion

Clear environmental advantages with use of LNG as fuel
Safeguarding life, property and the environment

www.dnv.com
DNV experience throughout the entire LNG Value Chain

- **Subsea**
- **Offshore production facilities (incl. storage, processing & liquefaction)**
- **Onshore liquefaction**
- **Transport vessel (LNG carriers)**
- **Terminal/storage**
- **End-user (gas distribution/power generation)**

LNG used as a maritime fuel

Break-bulk and small scale distribution
Addressing the entire project life cycle