NYNÄSHAMN LNG TERMINAL
THE FIRST LNG HUB IN THE BALTIC SEA

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Merchant LNG Europe & Marine
Agenda

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2) Clean Energy initiatives
3) LNG and safety
4) Key drivers for LNG terminal project
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The Linde Group
45,000 employees, turnover 13 bill EURO

No. 1 industrial gas company world wide
➢ Oxygen, nitrogen, argon
➢ Acetylene, fuel gases
➢ Welding process shielding gases
➢ Carbon monoxide, hydrogen
➢ Medical gases
➢ Rare gases, ultra-high purity gases
➢ Gas application processes and services
➢ Propane and LNG

Leading global engineering company
➢ Petrochemical, polyolefin plants
➢ Hydrogen, synthesis plants
➢ LNG, natural gas processing- and gas processing plants
Engineering capacity within the LNG value chain

- Liquefaction plants
- LNG carrier systems
- LNG receiving terminals
- Semi trailer
- Rail car
- Local storage
- Customer applications

Linde
> 320 ASU/hydrogen/LNG/specialty gases plants
Example: 4th largest energy consumer in the UK

ASU plants:
- > 10000 tpd $O_2$
- 2000-10000 tpd $O_2$
- 1000-2000 tpd $O_2$
- < 1000 tpd $O_2$
Linde Clean Energy initiatives

Europe
- Merchant LNG
- CCS (capture & CO2 transportation)
- H2 as fuel
Marine incidents
Gibraltar, May 2011 (newspapers stated fire in gas tank)
Ålesund, Norway September 2011 (Hurtigruten MS Nordlys)
LNG # marine fuels

- Cryogenic liquid
- Use protection clothes, gloves, boots
- Colorless, odorless, tasteless, non-toxic
- Density abt 0.43 kg/ltr
- LCV 13.7 kWh/kg vs diesel 12 kWh/kg
- Methane content 80% up to 99%
- Boiling point ~ 162 deg C
- Freezing point ~ 182 deg C
- 1 m³ liquid = 600 Nm³ gas
- Ignites in a 5-15% concentration in air
- Ignition temperature 542 deg C
- Burns slowly
- Use fire extinguisher or foam, not water
Key drivers for AGA’s LNG terminal in Nynashamn (2008)

- Supplier of and part owner in Norwegian LNG plant (Tjeldbergodden, Norway)
- AGA REN focusing on innovation and growth
- No expansion of gas grid in Sweden
- Initiatives to build LNG terminals had failed
- Fortum Gas to replace naphtha for Stockholm grid
- Nynas refinery to replace naphtha steam reformer
- Nordic LNG, Norway able to supply LNG
- Shipping capacity available (IM Skaugen)
- IMO’s proposal for SECA area
- LNG accepted as back up for growing biogas market
- No sign of the European financial crisis
- Linde able to combine Skangass LNG plant (advanced single flow process) with the Nynashamn terminal
Skangass LNG plant (Linde EPC contract)
AGA sole owner of the Nynäshamn LNG terminal
Adjacent to Nynäshamn refinery, Gotland traffic and Norvikudden

- Specialty products
  - Bitumen
  - Substantial upgrading
  - LNG replacing naphtha

- Traffic owned by the Swedish state
  - 1.4 million passengers, 640 km goods
  - Summer season 16 departures/day
  - Operated by Destination Gotland
  - Aim to introduce LNG/biogas

- Harbour of the future
  - 2 jetties, 1800 length, 60 acres
  - 300,000 TEU/year
  - Logistical centre 40 acres
  - 300,000 trailers/year
  - Railroad to the terminal
Nynäshamn LNG terminal – 3D layout
Key data LNG terminal

5 year from kick off to start up
Time from LOI to mechanical completion abt 25 months
Full containment LNG tank (EN 1473)
Total weight abt 21.000 tons, including LNG
Storage volume 20.000 m³ (9000 ton)
65.000 engineering and mgt hours
> 850 documents delivered
Dedicated jetty – up to 15.000 m³
Separate unit to liquefy boil off gas
Dedicated pipeline to Nynas refinery
2 truck loading units (> 20 trucks per day)
Prepared for second tank
Prepared for export
15 hours from first LNG received to operations
New LNG trailer design – 80 m³
Timeline of Emissions Regulations

**NOₓ Limits**

**Tier I: Global**
17.0 g/kWh - 9.8 g/kWh

**Tier II: Global for new ships**
14.4 g/kWh - 7.7 g/kWh

**Tier III: Current ECA & new ships**
3.4 g/kWh - 2.0 g/kWh

**IMO SOₓ Limits - Global**

4.5% max

3.5% max

0.5% max

**IMO SOₓ Limits - SECAs**

1.5% max

1.0% max

0.1% max

**EU SOₓ Limits**

0.1% max for all types of marine gas oils for ships at berth for longer than 2 hours in EU territory

0.1% max for certain fuels

*Source:* DNV’s MARPOL Annex VI Brochure, Wärtsilä, IMO http://www.imo.org
Norwegian NOx funding – a success story

- ~ 28% of the Baltic Sea is today defined as dead ocean
- ~2000 ships moving in/out at any time
- SOx emissions from Baltic shipping twice the Swedish and Danish land based emissions
- Low sulphur diesel, scrubber technology (LSFO) or LNG ship owner's alternatives

- Norway signed the 1990 Gothenburg Convention related to NOx emissions (~ 40 kton)
  - NOx emissions from Baltic shipping equal to Swedish and Danish land based emissions
  - Norwegian NOx Fund has been a success – acc. 18.000 ton NOx saved year end 2010
  - Oil and gas industry major financial contributor – cost effective solutions onboard ships/ferries
  - Abt 75% of LNG investment can be refunded under the new regime
CRYO AB LNG reference list – today more than 25 ships
It started with Glutra in 1999/2000
Retrofits and new buildings in Norway/Sweden

**Tresfjord** undergoes retrofit by STX from diesel electric into gas electric operations
- New gas engine
- New generator
- LNG tank
- Automatic systems
- Water systems
- Foam
- Backup systems etc

**Bit Viking** undergoes retrofit 2010/2011 by Wärtsilä installing “LNG Pack”
- NOx funded

New **Romsdalsfjord** ferries
- Mitsubishi GS16R-MPTK LNG generator
- Azimut thrusters STP 1010 each 1000 kW.
- Mitsubishi S12R-MPTA diesel back-up 1000 kW.
- Cryo AB LNG tank 125 m³
LNG unit – main components

- Tank
- Cold-box
- Cold-flare
- Bunker station
- Piping
- Nitrogen supply

Gas to engines

GVU
## Dual fuel vs. single fuel – some arguments

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<thead>
<tr>
<th>Dual fuel</th>
<th>Single fuel</th>
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<tbody>
<tr>
<td>✓ Double fuel systems = high safety</td>
<td>✓ Single system = less space</td>
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<tr>
<td>✓ Independent of LNG availability</td>
<td>✓ Lower investment, less complex</td>
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<tr>
<td>✓ Second hand value</td>
<td>✓ Lower consumption and emissions</td>
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<td>✓ More energy efficient</td>
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<tr>
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Cold box unit delivered by Cryo AB

- Water heated vaporizer
- Valves pneumatically operated
- All piping to safety relief valves
- No pumps needed
Materials used in the LNG facility

- Vessel – piping – coldbox in stainless steel
- Mild steel will cause brittle fracture in contact with LNG
Archipelago Stockholm and LNG

Viking Line first mover in the Baltic Sea

New Stockholm- Åbo ferry 2013

55,000 ton RoPax ferry

3 engines: HFO, MGO and LNG

2*200 m³LNG tanks on rear deck

LNG consumption > 20,000 ton/year per ferry

Safety and bunkering procedures are key issues
Supplying a marine client with LNG

1. By LNG semi trailer

2. From a permanent storage facility

3. By bunker: barge/ferry solution

4. From terminal via loading arms
Marine stakeholder’s views regarding LNG as fuel

Shell energy scenarios to 2050 (2008 report)

Never before has humanity faced such challenging outlook for energy demand on the planet. This can be summed up in five words:

“more energy, less carbon dioxide”
CEO Jeroen van der Veer

IMO Annex VI legislation
NOx emission reduction (TIER III - 2 gr/kWh 2016)
Sulphur content globally (max 0,5% 2020)
Sulphur content SECA/ECA areas (0,1 % 2015)
+ Energy efficiency index

New EU sulphur legislation

Tony Öhman, Viking Line (Stockholm Feb 2011)

- Support from harbour authorities
- Governmental funding
- Support from class societies
- Support from approval agencies
- Industry focus
- Global interest
- Technology in place
- Regulation in place
- Simple fuel system
- No treatment of emission gases
- Strong interest from ship yards
- Suppliers in place
- Cleaner working environment
- Cleaner engines
- Less cleaning needed
- Competitive price conditions
Fuel price will influence speed of introduction

Fuel prices in USD/MMbtu:
- ICIS NBP: 9.7
- ICIS Japan: 15.6
- Henry Hub: 3.6
- ICIS Brent: 19.9
- LSFO 1%: ~16.0
- MGO 0.1%: ~23.0

Quality in = quality out

Thank you for your attention