Experience from practice: Stockholm LNG terminal

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The Linde Group history

1879 Foundation of “Linde Eismaschinen AG” in Wiesbaden, Germany
1895 Carl von Linde patents “process of air liquefaction”
1907 Foundation of Linde Air Products, USA
1929 Take over of Güldner-Motoren-Gesellschaft (Diesel engine)
1959 Linde starts production of forklifts

1991 Take over of gas company Technoplyn, Czech Republic
2000 Take over of gas company AGA, Sweden
2006 Take over of BOC, Great Britain. Linde becomes The Linde Group.
2010 The Linde Group: Leading industrial gas and engineering company
2012 Take over Air Product’s European Health Care division

The Linde Group 2012
- Abt 50,000 employees
- World wide representation
- Turnover abt 13 bill EUR
- Engineering and Industrial gases
LNG safety and properties

- The simplest hydrocarbon – no oxygen molecules present
- Cryogenic substance – carbon steel reduces its ductility and becomes brittle
- Odourless, non-toxic, colourless
- Boiling point – 162 deg C at 1 bar (-149 deg at 2 bar)
- Adsorbed heat = latent heat of vaporization = 551 kJ/kg
- Lower explosion limit 5.3 – 14 %
- Density as liquid 450 kg/m3 – as vapour in atmosphere 6.8 kg/m3
- Danger of asphyxiation (< 10 % O₂, > 50 % CH₄)
- Danger of frostbite – use protection clothes, gloves, face mask etc
- Therefore “trap it, hold it, drain it, don’t run into it”
LNG fire training at Skangass LNG plant 2009

1. Boiling LNG – 2 m distance

2. Unconfined methane cloud ~95 m3 per minute

3. Ignited

4. Invisible fire - no smoke, low laminar flame speed, no overpressure

5. LNG burns backwards - flash fire (few seconds)

6. Water transfers heat – more intense fire
   Do not underestimate heat of transfer!

7. Power used in order to stop fire
   water to cool down the equipment
   danger of re-ignition from steel rod
Linde Group and LNG
We add customer value along the entire value chain

Production
- World-scale LNG
- Floating LNG
- Stranded gas
- Biogas

Terminals, smaller plants and equipment
- Terminal
- Small scale plants
- Pumps & vaporizers
- LNG tanks

Downstream distribution
- Trucking
- Bunkering
- Storage
- Fuelling

Customers
- Marine
- Transportation
- Industrial
**Linde product Line**

**Processes and projects**

**Indicative Project Size in Million €**

- **C₃H₈**
  - Mid-Scale LNG 50 tpd
  - STAR LNG 200+ tpd
  - World Scale LNG PDP/FEED/CWHE
  - NGL Plant C₃+ (100-400)

- **C₂H₆**
  - Mid-Scale LNG 1.300 tpd (PRC)
  - Mid-Scale LNG 900 tpd
  - FLNG 2.5 MTPA
  - NGL Plant C₂+ (500+ (EP))

- **CH₄**
  - STAR LNG 50-70
  - World Scale LNG 100-150
  - Mid-Scale LNG 60-85
  - Mid-Scale LNG 120-140
  - FLNG 500+ (EP)

- **N₂**
  - Mini LNG 20-30
  - Mid-Scale LNG 25-40 (EP)
  - NGL Plant C₂+ 50-70
  - Mid-Scale LNG 900 tpd
  - STAR LNG 200+ tpd
  - NGL Plant C₃+ 100-400

- **He**
  - NRU LNG Plant 60+
  - He-Plant 100+

- **N₂**
  - NRU EOR

<=300 MMSCFD per train: LPP >> 300 MMSCFD or Europe: LE-M
Delivery of 4 LNG production plants
- Statoil Tjeldbergodden (1997, 25 kton/y)
- Gasnor train 1 (2001, 40 kton/y)
- Snøhvit liquefaction plant (2007, 5 mill tpa)
- Lyse LNG plant, Stavanger (2010, 300 kton/y)
- Potential supplier of a LNG train 2 at Snøhvit

Delivered Gasnor’s LNG storage tank (4,000 m³)
Build, own and operate Nynashamn LNG import terminal (20,000 m³)
Operator of Gasum’s LNG plant in Porvoo, Finland
No 1 LNG supplier in Sweden
No 3 LNG supplier in Norway (former Statoil business)
No 1 biogas supplier in Stockholm area
No 1 cryo equipment supplier to marine sector in Scandinavia
LNG plant Tjeldbergodden (150 km south of Trondheim)
Supplying world’s first LNG ferry MF GLutra in 1999
AGA first mover in the Baltics in 2007
LNG project in Nynäshamn 60 km south of Stockholm

Linde Gas Sweden own, operate LNG terminal and sell/distribute LNG by road tankers
LNG terminal risk and safety management

- Continuous reporting of accidents and incidents
- Close cooperation with authorities, vendors and Nynas refinery
- Cooperation with Stockholm Hamn and Sjøfartsverket
- Hazop of terminal operations
- Quantitative and Qualitative risk analysis
- Job hazard analysis (permits, SHE analysis)
- Environmental work plan
- Work delegation
- HSE program construction, Contract quality plan etc.
Nynashamn LNG terminal
State of the art LNG technology

Operator and Owner:
Linde (AGA)

Tank Capacity:
20,000 m³

Start-Up:
May 2011

Berthing Capacity:
LNG Carriers up to 15,000 m³
Loading and unloading of LNG Dedicated jetty

- LNG carriers up to Length of 120 m
- Two Loading Arms (8" and 6" each) g
- Future export
LNG guidelines
Concrete-steel tank based upon EN 1473

- Full containment tank with pre-stressed concrete outer shell
- 21600 m³ operating volume
- Operating Pressure 1200-1300 mbar
- Two submerged LNG in-tank pumps
LNG terminal boil off gas
Cooling down by LNG or liquid nitrogen

- Boil-off gas compression
- Recondensation by mixing of compressed gas with LNG in a vacuum-insulated vessel
- Collection and intermediate storage in buffer tank with 250 m$^3$ capacity
Local distribution
2 truck loading facilities (3rd optional)

- Two Trailer Filling Stations
- Filling Station Loading Capacity of 75 m³/h
- Total Loading Capacity of 25 Trailers/d
- Incoming LNG Trailer Pressure 0 to 5 barg
LNG terminal supply nearby Nynas refinery
Dedicated gas pipeline from terminal to refinery area

- LNG Pressure Increase to 37 barg with Suction Pot Mounted Submerged LNG Booster Pumps
- Vaporization of LNG in a Coil Wound Heat Exchanger placed in a Steam Heated Water Bath
- Redundant Equipment Installation
- Send-Out Rate of up to 16000 Nm³/h
LNG flare
Required to take handle extraordinary situations

- Manual and automatic operation
- 8" flare line
- Overall heights at burner tip: 10 m
5 year from kick off to start up
Time from LOI to Mechanical completion some 25 months
Full containment LNG tank (EN 1473)
65,000 engineering and mgt hours
> 850 documents delivered
Prepared for second tank
Prepared for export
“T-REX”, Europe’s largest truck (80 m³)
Supply Stockholm Gas grid, distribution and industrial clients with LNG
Bunkering of LNG
Solutions for serving maritime industry

By **55-80 m³ LNG semi trailers** with pump capacity up to ~1000 ltr/minute

From **intermediate storage facility** consisting of LNG tanks from **250 up to ~1000 m³** with filling capacity up to ~ **3000 ltr/min via dedicated loading arm**

By bunker barge or vessel with capacity from **180 up to ~3000 m³**

From the **LNG terminal loading arm** with capacity up to ~ **1200 m³/hour**
Viking Line awarded AGA contract for Grace 55.000 dwt ferry to commence operations January 2013

Innovative supply chain:

Supply from Nynäshamn LNG terminal

Abt 1100 LNG trailer transports annually from Nynashamn to Stockholm port before traffic hour

As part of logistical solutions, in dept safety studies of Stockholm port traffic and Grace LNG bunker operation have been performed
Transfer of LNG between truck and bunker barge

At Loudden, operated by Port of Stockholm, transfer of LNG from truck to bunker barge will take place at a dedicated jetty area.

Transfer takes abt 3 hours.

Bunker barge goes to Stadsgården where Grace’s lay time is abt 1 hour.

Transfer of LNG to Grace based upon Ship to Ship bunker operation procedures.

LNG demand abt 60 ton per day and 22,000 ton per year.
Innovative bunker barge solution
Former Norwegian vehicle ferry

180 m³ LNG tank (4,3*11,3 m LNG tank) in stalled on deck

Manoeuvrable vessel – easy and simple to operate

In dept safety studies – as an example 12 knots collision test analysis

Tanker for Liquid Natural Gas and DnV class

Pressure Build Up (PBU) to ensure pressure needed to overfill from bunker barge to Grace

One delivery per day
LNG delivery
Ship to ship transfer between AGA barge and Grace

On line communication between the two vessels

6 inch in hose connection – no vapour return

Break away couplings installed

Time for bunker operation:

- 10 min to prepare and connect
- 45 min (3000 ltr/min) to perform bunkering
- 10 min to de-connect and departure

2*200 m³ LNG tanks on rear deck no 4

Mainly spray filling of Grace LNG tanks

Point of delivery where hose connects to vessel
Why LNG in the Stockholm archipelago?
Tony Öhman, Viking Line Stockholm Feb 2011

- Less emissions
- No treatment of emission gases
- Cleaner working environment
- Technology in place
- Competitive price conditions
- Support from harbour authorities
- Governmental funding
- Support from class societies
- Support from approval agencies
- Industry focus
- Global interest
- Regulation in place
- Simple fuel system
- Strong interest from ship yards
- Suppliers in place
- Cleaner engines
- Less overall cleaning needed
The Nordic experience
Some lessons learned

The Scandinavian industry has taken the lead to introduce LNG as maritime fuel

Some 74 ships expected on LNG within end 2015 requiring abt 300,000 ton of LNG

LNG technology for marine operations is well proven – both in the North Sea and the Barents Sea

Guidelines and procedures in place

Substantial emission savings when introducing LNG

Financial attractive alternative for the ship owner with less “wear and tear”
Thank you for your attention

http://www.the-linde-group.com

“I am taking the lead”

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Future oil and gas prices
Most likely fluctuating as in the past