The Linde Group
based on two pillars with extensive synergies
The Linde Group
Global >100 countries, 63’ people & turnover EUR 16.6 bn (2013)

Linde is market leader in 4 out of 5 emerging market regions
In our Gases Division long term investments include all aspects from source to customer.
Linde main supplier to the Scandinavian LNG development

— AGA part of cluster behind Norway’s first 20 kt/ y LNG plant, Trondheim, starting the marine LNG area in Norway
— EPC contractor of 40 kt/ y Gasnor Train 1, Bergen
— EPC contractor of 300 kt/ y Skangass LNG plant, Stavanger
— EPCS contractor of 4,3 mt/ y Statoil, “Snøhvit”, base load LNG plant, Hammerfest
— Supplied LNG equipment for LNG onboard storage in the North Sea to a majority of all current ships
— Built, own and operate Stockholm’s LNG terminal - first LNG import terminal in the Baltic Sea
— AGA awarded the contract to supply the first large LNG fuelled ship in the Baltic Sea, Viking Grace
Linde Engineering Division
Global Presence for the LNG Value Chain 2012

Technology, Execution & Manufacturing Centers
Major LNG & NGL Extraction EPC Jobs
LNG Facilities Owned & Operated by The Linde Group
Linde heavily engage in the complete value chain for small scale LNG beyond Scandinavia

Small to mid-scale liquefaction plants

Gablingen, Germany 21 tons per day
Tasmania, Australia 50 tons per day
Bergen, Norway 120 tons per day
Kwinana, Australia 175 tons per day
Stavanger, Norway 900 tons per day
Shan Shan, China 1,300 tons per day

Distribution & storage, refueling equipment and components

Linde owned small scale LNG operations

Australia
Altamont, CA, USA
Scandinavia
Main Installations - Functionalties

Gas Treatment

- Removal of water, condensate and other components (e.g. CO₂, H₂S, Hg, and others)

Liquefaction

- Pre-Cooling, liquefaction and sub-cooling using refrigerant cycles

Storage and Loading

- Storage under pressure or atmospheric pressure, loading of product by various means (e.g. ship, truck, etc.)

Safety and Security

- Installations for the plant security and process safety such as access control, CCTV, fire and gas detection, firefighting, emergency shut down, flare, etc.
LNG Processing Plant
What else is required?

Utilities - Functionalities
Power Generation and Distribution
- Power generation by gas turbines, transformation and distribution by switchgear to various consumers
Instrumentation and Control Installations
- Distributed Control System (DCS), fire and gas detection, control valves, etc.
Nitrogen, Instrument and Plant Air Supply
- Generation and storage of nitrogen, instrument and plant air
Run-Off, Sewage and Waste Water Treatment Systems and Installations
- Collection of run-off, sewage and other effluents
Buildings
- Administration building with central control room, workshop and warehouse
LNG Processing Plant - Block Diagram
How to keep track and the overview?
Liquefaction Process
What does a simple expander process look like?

**Typicals**
- simple process, low equipment count
- nitrogen or mixed refrigerant ($N_2$, $CH_4$) cycle at one pressure level
- pre-cooling, liquefaction and sub-cooling realized in one heat exchanger (aluminum plate fin heat exchanger)
- specific energy consumption approximately 600-700 kWh/ t LNG
- investment volume <50 Mio. €
## General market opportunities for small-scale LNG

### Marine Sector

**M/S Bergenfjord (2x 125 m³ tank)**

### Mobility

LNG truck fuelling station Stockholm

### Industry & Power

Nynäshamn Terminal
Supply of nearby Refinery

### Status

- Due to regulation and price development huge interest by shipping industry
- More than 20 ships equipped with tanks from Cryo AB
- Viking Grace from 2013 fuelled by LNG

### Price benchmark

- ECA: MGO or HFO + scrubber
- Deep Sea: HFO

### Status

- OEMs (Volvo, Westport, MAN, ...) developing technology
- First LNG refuelling station in Stockholm in operation, 2 more to come in 2012

### Status

- In stranded areas without connection to trans-european grid, gas supply alternative
- Interest from various industries to substitute other fuels with natural gas

### Price benchmark

- Diesel

- LPG, Diesel, Naphtha
## Experience from current operations

### Australia

<table>
<thead>
<tr>
<th>LNG truck fuelling station installed October 2012, Victoria</th>
</tr>
</thead>
</table>

**Status**
- Small scale plant capacity exist on both East and West coast
- Appreciation of AUD hampers development
- Lack of suitable vehicles, OEM backed vehicles

### North America

<table>
<thead>
<tr>
<th>BioLNG plant in Altamont California</th>
</tr>
</thead>
</table>

**Status**
- Huge spread between diesel and natural gas price
- Oil & Gas industry early adaptor of LNG to displace diesel
- Several players announced significant investments in infrastructure

### Europe, UK & Scandinavia

<table>
<thead>
<tr>
<th>LNG truck fuelling station Stockholm</th>
</tr>
</thead>
</table>

**Status**
- First few stations installed
- Economic drive relative low but strong interest for bio methane
- Good cooperation within industry
**Truck Fuel Station** (Pumped)

**Typical Process Schema**

- Bulk fill
- Bulk tank
- 'Warm' LNG
- 'Cold' LNG
- LIN Assist option
- LIN
- Pump
- Saturator option
- Two hose option
- Onboard tank
LNG Truck Fuel Station in UK
Linde’s Intention: Establish LNG as Alternative Fuel

Success Factors

LNG Supply:
- Secured LNG supply from large scale, centralised entry points (i.e. LNG import terminal) or local LNG production direct or over small-scale LNG terminals to customers
- No seasonality for freight haulage as for established gas markets
- Price formula and contracting according to needs for heavy truck operation

LNG infrastructure:
- Chicken-egg problem persist – funding to establish multiple access points to LNG for road transport network, e.g. public or customer specific
- Established and EU wide harmonized legislation and standards required
- Technology need to fulfil user and environmental requirements

Customer:
- Availability of OEM backed products
- Commercially viable business case

Security & cost of supply, availability of infrastructure and OEM backed products must come together to generate growth and avoid disappointment on either side during early market introduction.
Thank you for your attention.