WÄRTSILÄ’S ROLE IN THE GAS VALUE CHAIN

TORE LUNDE
Director, Wärtsilä Oil & Gas Systems
World Energy Outlook 2012 by OECD/IEA: Major global trade flows 2035

- Gas consumption expected to increase >30% by 2035
- Long-term growth mainly driven by power production
- CO₂ emissions reduced by 60% compared to coal
- Highest demand growth in emerging economies/non-OECD countries
- Mismatch between location of resources and consumers
Liquefaction – Natural gas is cooled down to -160 degrees Celsius, at which point it becomes liquid. By liquefying the natural gas the volume shrinks 600 times, thus making it cost efficient to transport over long distances.
LNG and LPG distribution/shipping value chain

### Source

- **Natural gas wells**
- **Oil wells**

### Processing

- **Gas plant**
- **LNG liquefaction**
- **Ammonia plant**
- **Petrochemical cracker**
- **Refinery**

### Products carried

- **LNG**
- **LPG/LEG**
- **Condensates**
- **Ammonia**
- **Petrochemical gases**
- **Clean products**
- **Dirty products**

### Transport

- **Pipeline**
- **LNG ship**
- **LPG/LEG ammonia ships**
- **Cargo cap. range**
  - Fully pressurized (FP): 1,000-11,000 m³
  - Semi refrig./press.: 1,200-23,000 m³
  - Fully refrigerated (FR): 22,000-85,000 m³
  - Small size LNGC: 1,000-30,000 m³

### Users

- **Power generation**
- **Residential/Commercial**

*2% of energy market, of which 24% transported on ships (~60 mt)*
LNG and LPG distribution/shipping value chain

Source
- Natural Gas wells
- Oil Wells

Processing
- Gas plant
- Refinery
- LNG liquefaction
- Ammonia plant
- Petrochemical cracker

Products carried
- LNG
- LPG/LEG
- Condensates
- Ammonia
- Petrochemical gases
- Clean products
- Dirty products

Transport
- Pipeline
- LNG ship
- LPG/LEG ammonia ships

Users
- Power generation
- Residential/Commercial
- Industrial
- Autofuels: bus, taxi, car
- Further refining
- Chemical
- Agriculture
Our expertise in the gas value chain

- **Exploration & Drilling**
  - LNG fuel gas systems for OSVs
  - On- & Offshore small scale liquefaction
  - Antiflaring/VOC
  - Oil separation
  - Gas FPSO

- **Production & liquefaction**
  - LPG, LEG & LNG cargo handling

- **Transport & storage**
  - LNG fuel gas systems

- **Receiving terminals & regasification**
  - Jetty & Floating regasification
  - Bunkering & barges
  - Receiving terminals

- **Distribution & transport to the users**
  - Gas/LNG distribution/logistics
  - Feed gas to Power plants

- **Distribution & transport**
  - LNG carrier
  - Flare recovery
  - Oil separation

- **Power generation**
  - LPG/LEG/LNG tankers

- **LNG terminal & Regasification (FSRU/JRU)**

- **Small-scale LNG plants**
  - LNG carrier
  - FPSO

- **LNG bunkering & barges**
  - LNG fuellved vessels

- **LNG liquefaction & terminal**

- **Oil tanker with VOC**
Gas solutions – LPG/LEG & multigas carriers

Reference: Series of multigas carriers for Evergas

Package with integrated:
- cargo handling system
- gas supply system
- propulsion systems

Market development
- Increased LNG production & shale gas production will impact trading & trade patterns
- Regional & local LNG terminals, coastal transport and LNG bunkering will grow
- Newbuild market is expected to remain strong for all gas ship sizes/types
- China and Korea dominate newbuilding of gas carriers, global owners will participate in supplier selection
Gas solutions – LNG

Reliquefaction and Regasification

LNG C "Al Bahiya"
- Q-flex built as DSME, operated by STASCO
- Equipped with Hamworthy’s Mark III LNG Reliquefaction system

FSRU "Golar Freeze"
- Owned by Golar LNG Energy
- Equipped with Hamworthy’s Regasification system

COOL DOWN (reliquefy) ↔ WARM UP (regasify)
Gas solutions – LNG regasification

Floating Storage and Regasification Unit (FSRU)

FSRU moored at a jetty receiving LNG from a LNGC

- Why such solutions:
  - Increased demand for clean energy, power shortage, diversification, lack of gas infrastructure, easier permits, fast track, relocation possibility, cost competitive
- Gas supply goes normally to power plant or city pipeline, typically 10-30 M Sm3/d @ 100 bar
- Applied for newbuilds, retrofit on existing LNG carriers, barge or directly on a jetty
- Fast track project: ~18 months for conversion, typical lease of FSRUs imply low CAPEX
- The current demand for LNG creates many opportunities in e.g. SE Asia, ME, India, China, S America – currently about 30 new opportunities
Gas solutions – LNG regasification

Regasification systems for FSRUs and jetty installations

- Seawater-propane: 3 x 221 tons/h trains (3x50%)
- Send-out pressure and capacity: 70 bar / 442 tons/h (500 MMscf/d)
- Single-lift module: 32x20x13 m, 945 t dry weight
- BOG recondenser capacity: 24 tons/h per train

Jetty Regasification Unit for Petronas’ LNG terminal Melaka, Malaysia – March 2012
Gas solutions – LNG regasification

Regasification systems for FSRUs and jetty installations

Order book:
Deliveries to 4 Floating Storage Regasification Units (FSRU) at HHI for Höegh LNG
Gas solutions – LNG terminals and distribution

Wärtsilä’s competitive advantage based on scope of offering

- Ship design and main equipment
- Supply of LNG terminal
- Supply of Power Plant
- Operation
- Maintenance
- Financing
Gas solutions – LNG terminals

Typical LNG terminal EPC scope of supply

**Ship Power:**
- BOG compressors
- Vapour return blowers
- LNG-in-tank pumps
- Vaporiser units
- Plant process engineering
- Control system
- Process guarantee

**Power Plants:**
- Civil works
- LNG storage tank
- Loading arms
- Buildings
- Flare
- Installation
- Piping
- Electrical
- Fire fighting
- Power plant
Gas solutions – LNG liquefaction

Small scale LNG production

- Feed gas
  - Biogas
  - CBM
  - Flare gas
  - Pipeline / well head gas

- LNG production
  - SSL
  - MiniLNG

- Storage

- Transportation & distribution

- End users
Gas solutions – LNG liquefaction

Our area of operation in the LNG production space

MiniLNG → 20k t/y
Small scale LNG 20 -500k t/y
Medium scale LNG 0.5 -2 MMTPA
Large scale LNG 2 -7+ MMTPA

Small scale technologies

REFERENCES

Oslo; 4k t/y
Sköldvik; 20k t/y
Snurrevarden; 22k t/y
Kollsnes; 84k t/y

Large scale technologies

AS COMPARISON

Prelude FLNG; 5 MMTPA
- Technip Samsung Consortium contracted by Shell

PLAYERS

Air Liquide
Cryostar (Linde)
GE/Salof
BOC

Linde
Air Liquide
GE/Salof
Black & Veatch

CB&I Lummus
Dresser Rand

Air Products
Linde
ConocoPhillips
Shell

We are a small scale contractor offering mini, small scale and medium scale liquefaction plants with production capacity up to 1 MMTPA
Small Scale LNG production – References

- **Snurrevarden**
  - First free-standing small scale LNG plant in Northern Europe delivered March 2003
  - EPCIC contract with GASNOR
  - Technology feasibility and robustness demonstrated

- **Kollsnes II**
  - 2 x capacity of Kollsnes I (Linde plant)
  - EPCIC contract with GASNOR
  - Contract awarded fall 2005, full production August 2007
  - Liquefaction process based improved Brayton cycle compared with Snurrevarden

- **Gasum, Finland**
  - EPCIC contract w/o civil work
  - Liquefaction based on liquid N2 from nearby separation plant
  - Tank capacity 3 x 689 m³
  - Start-up June 2010
Gas solutions – new gas liquefaction process

**New MR test plant – Moss, Norway**
- Test plant for newly developed Multi Refrigerant liquefaction process
- LNG liquefaction capacity 100kg/h
- In operation as of March 2013
- LNG in closed loop, evaporated by air heater
- Verified technology and process simulations

**Biogas liquefaction plant – Oslo, Norway**
- Our 1st commercial biogas liquefaction plant
- Biogas created from household organic waste
- Liquid Biogas (LBG) to be used on city buses
- LBG production capacity 11tons/day
- Production started October 2013
- Includes gas pre-treatment, liquefaction, storage and export

**ONGOING DEVELOPMENTS**
- Standardise solutions for different capacities
- Use feed-gas from different types of sources
- Versions for marine application (BOG reliquefaction)
Gas fuelled vessels – market drivers

- **Main drivers** for the gas fuelled vessel market:
  - Environmental awareness & regulations
  - Fuel price
  - Gas availability

- **Environmental incentive**
  LNG enables emission reduction:
  - $\text{NO}_x$ – 92%
  - $\text{CO}_2$ – 23%
  - $\text{SO}_x$ – 100%
  - Particulates – 100%
Gas solutions – LNG fuel systems

LNGPac – Reference: Viking Grace

- Wärtsilä market leading position in dual-fuel engines supports Gas Solution’s growth ambitions
- We have also developed concepts for bunkering vessels/barges, further facilitating the transition to using LNG as the primary marine fuel