Small scale LNG production plant to Serve Marine Sector

LNG Bunkering Seminar
Klaipėda, October 17th 2014
GE Oil & Gas becomes an independent business reporting directly to GE Corporate
From extraction, to transportation, to end use ...

- Gas Storage & Pipeline
- Offshore Oil & Gas Production
- Drilling
- LNG Refining & Petrochemical
- Services & Predictivity
- Skills Development
- Subsea
- Distributed Gas
- Power Generation

Cutting edge technology & service solutions across the value chain
Building on a strong foundation...

(Orders $ in billions)

1994
A Turbomachinery company

1997
Developed a Service model

2004
Expanded in Inspection Technologies

2007
Well Support
- Pressure Control
- Electrical Submersible Pumps
- Logging Services

2008
Entered the Drilling & Production segment

2011
The “new” GE Oil & Gas

2012
GE Oil & Gas became stand-alone GE segment

2013
Continue to build out capabilities to focus on specific segments

ACQUISITION STRATEGY FOCUSING ON HIGH-GROWTH AREAS ACROSS THE VALUE STREAM

$1
Closed on May 31st

$2
Closed on July 1st

$4
Closed on May 31st

$10
Closed on July 1st

$15.2
Closed on May 31st

$18.2
Closed on July 1st
Our technology solutions

Subsea Systems
- Subsea trees & wellheads
- Subsea power & processing
- Controls
- Manifolds
- Flexible risers
- Flow lines
- Specialty connectors & pipes

Drilling & Surface
- Drilling risers
- Blow-out preventers
- Electric submersible pumps
- Logging while drilling & wire line tools
- Surface wellheads & flow control
- Logging services

Lufkin
- Artificial lift: rod lift, gas lift, plunger lift, progressive cavity pumps, hydraulic pumping units
- Service & repair
- Engineered industrial gears
- Fluid film bearings

Measurement & Control
- Asset condition monitoring, control sensing & inspection solutions
- Optimization & diagnostic software
- Pipeline inspection and integrity services
- Control & safety relief valves
- Fuel dispensers & payment terminals
- Fuel control & retail systems

Turbomachinery Solutions
Turbomachinery equipment and services for the upstream, midstream and LNG segments including:
- Gas turbines
- Axial & centrifugal compressors
- Electric motor driven compressors
- Turn-key industrial modular solutions
- Turboexpanders & heat exchangers
- Contractual & maintenance services
- Upgrades & industrial applications
- Monitoring & diagnostics

Downstream Technology Solutions
Equipment & services for the refinery & petrochemical, distributed gas and industrial applications including:
- Steam turbines
- Reciprocating compressors
- Distributed gas solutions – small LNG & CNG
- Pumps, valves & distribution systems
- Blowers & compressors
- Maintenance services & remote monitoring & diagnostics

Delivering customer solutions by applying systems-level engineering across the portfolio

~43,000 employees
~$17B revenues ’13

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LNG / CNG solutions to serve our customer
Marine Emission regulations

- IMO Protocol MARPOL Annex VI (in force since 2005) set limits on Fuel Sulphur NOx
  - Jan 2012 – Fuel Sulphur content < 3.5% for all vessels globally
  - Jan 2015 – Fuel Sulphur content < 0.1% for all vessels in Sulphur ECA area
  - Jan 2016 – NOx emissions reduced 75% below Tier II for new vessels in ECA area
  - Jan 2020 - Fuel Sulphur content < 0.5% for all vessels globally
- .... what will be next ??

- Not only limited to Baltic, North Sea and North America coastline but will expand ...

- Large impact on Marine Industry

.... is there a solution ?
Natural Gas
is the only fuel able to comply without SCR, with TIER III-NOx and SO2 restrictions in the ECA zones

... CLEAN
- CO2 gr/MJ: LNG > Diesel-Kero by 25%
- NOx mgr/MJ: LNG > Diesel-Kero by 85%
- SO2 mgr/MJ: LNG > Diesel-Kero by 95%
- PMx mgr/MJ: LNG > Diesel-Kero by 99%

... AVAILABLE (security of supply)
- Gas reserves: 10,670 TWH
- NG > 3 times more abundant than oil

... SAFE
- Gas is not toxic
- Gas is less flammable
- Gas is lighter than air
- Used at home
- Easy to handle

... Efficient
- High energy density

... Economic

.... how GE O&G can bring NG closer to you
.... Gas supply chain

Source

- Stranded gas
- Gas Pipeline
- Biogas
- Flared gas

CNG Based Solution

- Pre-Treatment
- CNG In A Box™
- Transportation

LNG Based Solution

- Small scale LNG solutions
- Transportation
- LNG users

Options: sulfur, water, CO₂, heavy hydrocarbons

Demand

- CNG users
- Gas Pipeline
- CNG users
- LNG users

Gas Pipeline

Biogas

Stranded gas

Flared gas

GE imagination at work
Small Scale LNG Solutions
GE experience in large scale LNG

GE technology used globally in large scale LNG liquefaction

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Small Scale LNG
GE O&G Acquires Salof Companies – June 2013

Headquartered in San Antonio, Texas
Installed facility base of over 130 plants worldwide

- 11 LNG plants (1 Australia, 10 China)
- 12 LNG plants in backlog (1 Canada, 11 US)
- 2 NG Processing plants (1 Saudi Arabia, 1 Libya)
- 120+ LCO₂ plants (Worldwide)

330,000 ft² Manufacturing Facility in Schertz, TX
300 employees and growing

Practical Applications:
- Industrial Refrigeration
- LNG & CO₂ Liquefaction Facilities
- Off/onshore Gas Processing and Conditioning
- International Engineering Services
- Operation and Maintenance Services
- Plant Automation
SALOF acquisition value propositions

1. **Fully Integrated** Plant vs. equipment only (~ turnkey)
2. Multiple LNG processes
   - EXP – self made refrigerant (similar to N² loop), uses BOG
   - PCMR - Pre-Cooled Mixed Refrigerant
   - SCMR - Single Cycle Mixed Refrigerant
3. Plant Supply
   - Stick Built – “one-off” key strategic deal
   - Modular – larger sites
   - Fully Modular Plug-n-Play – installation speed, cost
4. **ICL** – minimize MR makeup; footprint, sound...all ICL benefits
5. **BOP - GE scope** (compressors, valves, controls, etc.)
6. **Reference** list, quality, safety and reputation
LNG Plant Design
Gas Processing and Liquefaction

Compression (if required)
Gas Sweetening:
CO₂ removal < 50 ppm
H₂O removal < 1 ppm
H₂S removal < 5 ppm
Hg, BTEX, Mercaptan, Benzene Removal

Multiple LNG Refrigeration Processes
EXP – comp/exp boil off gas refrigeration
N² – comp/exp nitrogen refrigeration
PCMR – pre-cooled mixed refrigeration
SCMR – single cycle mixed refrigeration
Gas Sweetening

<table>
<thead>
<tr>
<th>Natural Gas</th>
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<tbody>
<tr>
<td>Source</td>
<td></td>
</tr>
<tr>
<td>Inlet Gas Pressure (min, max)</td>
<td></td>
</tr>
<tr>
<td>Inlet Gas Flow, LNG plant capacity</td>
<td></td>
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<tr>
<td>Inlet Gas Temperature</td>
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</table>

<table>
<thead>
<tr>
<th>Composition</th>
<th></th>
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<tbody>
<tr>
<td>Methane C1</td>
<td></td>
</tr>
<tr>
<td>Ethane C2</td>
<td></td>
</tr>
<tr>
<td>Propane C3</td>
<td></td>
</tr>
<tr>
<td>i-Butane i-C4</td>
<td></td>
</tr>
<tr>
<td>n-Butane n-C4</td>
<td></td>
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<tr>
<td>i-Pentane i-C5</td>
<td></td>
</tr>
<tr>
<td>n-Pentane n-C5</td>
<td></td>
</tr>
<tr>
<td>Neo-Pentane Neo-C5</td>
<td></td>
</tr>
<tr>
<td>Hexane + C6+</td>
<td></td>
</tr>
<tr>
<td>Benzene C6H6</td>
<td></td>
</tr>
<tr>
<td>BTEX (benzene, toluene, ethybenzene, xylenes)</td>
<td></td>
</tr>
<tr>
<td>Nitrogen N2</td>
<td></td>
</tr>
<tr>
<td>Carbon Dioxide CO2</td>
<td></td>
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<tr>
<td>Hydrogen Sulfide H2S</td>
<td></td>
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<tr>
<td>Mercury Hg</td>
<td></td>
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<tr>
<td>Water H2O</td>
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</table>

Inlet Compression (if needed):
- Reciprocating
- Centrifugal

Gas Sweetening:
- Amine Plant for CO₂ and H₂S Removal
- CO₂ removal with molecular sieve (MS) (option)
- Hg guard beds (or with MS)
- MS for water removal
- MS for BTEX removal
- Acid gas clean up

LNG Specification:
- Allowable limits of impurities in LNG?
- Storage tank pressure?
Liquefaction Technologies

Reverse Brayton Cycle
Compression/Expansion
- Nitrogen
- Methane (BoG)
Pros:
  Refrigerant sourcing
  No liquid HC refrigerant
  Ease of operation
  Minimal cryo equipment
Cons:
  Efficiency
  Seal gas loses

Mixed Refrigerant
- SCMR single cycle
- PCMR precooled
Pros:
  Efficient (30% vs. C/E)
Cons:
  Source Refrigerant
  Seal gas loses (except ICL)

Technical Differentiators
- Compression options: reciprocating, centrifugal, ICL (no Environmental emissions), screw
- Compressor driver: gas engine, gas turbine, electric driver
- Storage tank pressure, ability to source refrigerants, ambient conditions, etc.
Engineering

In House Design

- Process modeling to meet client specific project
- "Smart" Piping & Instrumentation Diagrams (P&ID)
- 2D/3D Design allowing plant walk through
- Modularized design
- Pipe stress and structural analysis
- Process safety design
- Meeting worldwide code requirements
LNG Plant
Modular Design and Manufacturing

MODULARIZATION BENEFITS
Labor Cost
Schedule
Quality
Productivity
Safety
Mechanical interface
Electrical Power Rooms
Prewired Control Houses

Available Options:
- MCMCC and LVMCC
- Main Control Panel
- UPS
- Fire Detection
Electrical Control
Instrumentation, PLC, and Full Plant Control Systems
MCC and Operations Rooms

Managed cable trays under the elevated floor for quick install and easy troubleshooting
Module Setup and Installation

Modular design reduces field setup time
Shipping and Transport

Crated and Ready for International Transport
Example of Modular Plug-n-Play

[Image of a modular plug-n-play system]
Single Point Field Connection
Installed On Site
LNG Facility
LNG Plant and Balance of Plant (200 tpd ~ 10 MMscfd)
# Small Scale LNG References

<table>
<thead>
<tr>
<th>Year / location</th>
<th>MMscfd</th>
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<tbody>
<tr>
<td>2004 Weizhou Island China</td>
<td>6</td>
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<tr>
<td>2005 Karratha, WA</td>
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<tr>
<td>2009 Inner Mongolia, PRC</td>
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</tr>
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<td>2010 Tianfu, PRC</td>
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<tr>
<td>2010 PRC</td>
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<tr>
<td>2010 PRC</td>
<td>2 x 4.4</td>
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<td>2010 Karamay, PRC</td>
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<tr>
<td>2011 PRC</td>
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**Operational**

<table>
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<tr>
<th>Year / location</th>
<th>MMscfd</th>
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<tr>
<td>2012 Calgary, Canada (Shell)</td>
<td>38</td>
</tr>
<tr>
<td>2013 USA (Shell)</td>
<td>10 x 36</td>
</tr>
<tr>
<td>2013 USA (BLU Lng)</td>
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<tr>
<td>2013/14 RUSSIA</td>
<td>2 x 8.1</td>
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<tr>
<td>2014 Canada</td>
<td>8.1</td>
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**Backlog**

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10 MMscfd => ~ 75,000 Tons per year LNG (345 days)
SUMMARY

Bringing GE-proven LNG experience to rapidly deployable, small-scale solutions

GE solutions to help our Customer
Questions
Thank you for your attention

GE imagination at work