Some simple definitions:

LNG: Liquid Natural Gas (>98% methane)
LPG: Liquid Petroleum Gas (propane, buthane etc.)
VOC: Volatile Organic Compounds (vapor from crude oil)
Hamworthy Gas Systems

Where are we?
Hamworthy Gas Systems

What are we?

- International company owned by Hamworthy PLC in UK
- Listed on the London Stock Exchange
- Largest company in the Hamworthy group
- Total commitment to innovation
- High tech products for production and transportation of oil & gas:
  - Cargo handling on gas carriers & FSO/FPSO’s
    - Reliquefaction systems for LPG, LEG & LNG
  - Recovery of VOC from crude on shuttletankers/terminals
    - Condensation of VOC with 100% emission reduction
  - Regasification directly from LNG-carriers/FSRU
  - LNG production onshore and offshore
    - Small scale plants e.g “Snurrevarden” (30 tonn/day)
    - Mini LNG-plants (Sintef) (8 – 30 tonn/day)
    - Floating LNG production
Hamworthy Gas Systems

Where do we come from?

200 years of industrial heritage

VOC recovery modules

Complete LPG Cargo systems

Ship and FPSO pumps and inert gas

LNG tanker design

LPG FPSO
Hamworthy Gas Systems

Who are we?

202 employees in Asker, Norway
...growing rapidly!

24% women.
15% women in engineering.

Average employee age is 39.
Age range 22 - 66.
Our technology in the gas market...
The value chain

Hamworthy Gas Systems in the LPG/LNG production and transportation chain

- Offshore liquefaction
- Small scale Liquefaction plants
- Transportation: reliquefaction
- Floating regasification systems
- LPG FPSO
LNG Liquefaction

From natural gas to purified LNG at -163°C

- Two stage system:
  - Pre-treatment (gas purification)
  - Liquefaction (cooling to liquid state)
- Gas pre-treatment:
  - Filtration and pressure reduction
  - Sweetening (CO₂ removal)
  - Dehydration (H₂O, glycol, Hg removal)
- Liquefaction based on N₂ cycle
LNG Onshore Liquefaction

Hamworthy Gas Systems’ LNG plants at Snurrevarden and Kollsnes

Snurrevarden, Karmøy, start-up March 2003

First free-standing small scale LNG plant in Scandinavia. Capacity 60 ton LNG per day. Unmanned operation.

Kollsnes II, Øygarden, start-up July 2007

Production capacity 240 ton LNG per day, supplying LNG to local ferries, coastal vessels and local industry (ferrosilicium/aluminium).
Floating Liquefaction Natural Gas FLNG

Market potential

- Approximately 25% of the world’s gas reserves is "unavailable" offshore fields (stranded gas)
  - FLNG makes it available!
- Estimated 10 billion ft³ gas flared worldwide every day
  - FLNG can make flaring history!
- Several analyses of projects under development show that FLNG costs compare favorable to land-based LNG production
Where do we stand in this new market?

- Several projects in bid phase, ongoing studies
- Rapidly increasing interest among investors, shipowners and energy companies
- Established technology fit for FLNG
- Unique position within LPG/LNG liquefaction and processing systems – land-based, marine, and offshore!

Modules for Floating Liquefaction of Natural Gas (FLNG) shown on section of LNG vessel.
Mini LNG plants

Market potential

- Local utilization of natural gas in areas without central pipeline connection.
- Gas from local reservoirs, pipeline, landfills, flare, gas wells or coal mines.
- Sizes from 1 – 50 tons LNG per day.

Patented µ - LNG plant, licenced by SINTEF
LNG transport

Traditional propulsion system in LNG carriers

LNG carriers built in the 1970s used boil-off gas from the cargo as fuel in turbine propulsion systems. The consequences were:

• Expensive fuel and reduced payload
• Higher CO2 emissions
• Low efficiency of turbines
• Lack of crew with turbine qualifications
• Existing turbine design is at a limit to provide the power required by new large LNG carriers

Option: Use other type of propulsion and return boil-off gas to the tank in liquid state.

Re-liquefaction!
Newbuild LNG carriers (post 2006 - 1,260 ships):

- ST 50%
- SSD 29%
- DFDE 21%

100% HGS reliquefaction systems

How did we get this piece of cake?

Source: WoodMackenzie & Clarkson

<table>
<thead>
<tr>
<th>Propulsion type</th>
<th>Relative energy consumption (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Slow Speed Diesel</td>
<td>66</td>
</tr>
<tr>
<td>Diesel electric</td>
<td>72</td>
</tr>
<tr>
<td>Gas turbines</td>
<td>84</td>
</tr>
<tr>
<td>Conventional steam turbine</td>
<td>100</td>
</tr>
</tbody>
</table>
LNG transport

Leading the way in LNG Reliquefaction Systems

- **Innovation - significant reduction in power consumption**
- **Mark I** — First 20 vessels
- **Mark II** — Developed for small scale onshore units
- **Mark III** — Last generation LNG Carriers (11 orders)

31 reliquefaction units contracted with Hamworthy so far...
Import & spot/short term LNG trading is increasing

Existing import terminals are booked or have limited capacity

Difficult to get permission to build new onshore terminals in US and Europe

Vaporization plant onboard LNG carriers or Floating Storage Units will not need onshore terminals
What is a shuttle regasification vessel?

"A slightly modified standard LNG carrier"

Onboard LNG regasification plant located on deck

LNG storage within the ship’s hull

Mooring and gas export system
Typical Scope of Supply to new-builds:

- Engineering of Cargo Handling System
  - P&ID’s, Arrangement, Automation
  - Main Cargo Tanks & Deck Tanks
- Equipment Supply
  - Reliquefaction Plants
  - Cargo Heat Exchangers
  - Cargo Control & Monitoring system
  - Valves, Instruments, etc.
  - Inert Gas & N₂ Generators
  - Svanehøj Cargo Pumps
  - Commissioning and supervision

60 ship references contracted last 8 years for typical customers:

- Hyundai, Daewoo, Kawasaki, Gdynia
- Bergesen, Geogas, Solvang, Exmar, A.P.Møller, Sonatrach, Stena, SK-Shipping, AMPTC, K-Line

Daewoo and Hyundai Ship-Yard in Korea
Volatile Organic Compounds recovery

Typical emissions from crude oil cargo tanks each voyage

Current international practice

Norwegian authorities’ minimum requirements (1st generation)

Hamworthy
Global environmental challenge

Flare gas

Associated gas production can create a problem.

If there are no infrastructure/pipelines, gas is either flared or regulations are such that oil cannot be recovered without gas solution.

Alternatives are to liquify all the gas or to produce power from the light hydrocarbons and liquefy the heavier hydrocarbons, then store the liquid onboard for export:

Hamworthy solutions based on our LNG, LPG or VOC technology!
## Environmental summary

**HGS in an environmental perspective**

<table>
<thead>
<tr>
<th>HGS product</th>
<th>Environmental contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG Carrier Reliquefaction</td>
<td>Reduced emissions</td>
</tr>
<tr>
<td></td>
<td>Reduced power consumption</td>
</tr>
<tr>
<td>LNG Carrier Regasification</td>
<td>Reduced local environmental impact</td>
</tr>
<tr>
<td></td>
<td>Reduced HSE risk</td>
</tr>
<tr>
<td>Small Scale LNG Plants onshore or offshore</td>
<td>Reduced emissions</td>
</tr>
<tr>
<td></td>
<td>Reduced HSE risk</td>
</tr>
<tr>
<td></td>
<td>Increased flexibility in energy supply</td>
</tr>
<tr>
<td>Mini LNG Plants</td>
<td>Reduced emissions</td>
</tr>
<tr>
<td></td>
<td>Increased flexibility in energy supply</td>
</tr>
<tr>
<td>VOC recovery</td>
<td>Zero VOC emissions</td>
</tr>
<tr>
<td></td>
<td>Marketable recovery product</td>
</tr>
</tbody>
</table>
Join the fun!