American Institute of Marine Underwriters

State of the LNG Industry: A Class Perspective

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New York City
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Overview

• Ship Capacity and Trends
• Technology Update
• Offshore LNG Terminals
LNG Carrier Outlook

LNG Demand

- LNG is a major share of the total natural gas currently consumed in several countries, particularly in Asia
- LNG imports to the US market are expected to rise significantly, tripling by 2010 and quadrupling by 2015

More ships, more terminals, more LNG

- LNG trade is widely forecast to grow by at least 7% per annum over the next decade, almost tripling the quantity traded today
- Rapid growth has attracted new entrants
- Short-term and spot trades will become increasingly more common
- Many Offshore regasification terminals are under consideration

Source: IEA, Drewry, OSC & Fairplay
Major Natural Gas Trade Movements

Trade flows worldwide (billion cubic metres)

Source: BP Statistical Review of World Energy 2005
LNG Carrier Fleet

Number of Ships & When Built – September 2005

September 2005 Orderbook = 66% of existing fleet
(In number of ships and a larger % in capacity)

Existing Fleet (185)

The significant fleet expansion experience the past few years will continue at an even higher level

Source: Clarkson
## LNG Order Book Deliveries
(by Shipyard)

<table>
<thead>
<tr>
<th>Shipyard</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daewoo S.B.</td>
<td>2</td>
<td>9</td>
<td>8</td>
<td>12</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Samsung S.B.</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>11</td>
<td>4</td>
<td>0</td>
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<tr>
<td>Hyundai H.I.</td>
<td>1</td>
<td>1</td>
<td>10</td>
<td>7</td>
<td>3</td>
<td>0</td>
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<tr>
<td>Mitsui S.B.</td>
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<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Kawasaki H.I.</td>
<td>2</td>
<td>3</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Mitsubishi H.I.</td>
<td>1</td>
<td>3</td>
<td>3</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hudong Zhonghua</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
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<tr>
<td>Izar</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>De l'Atlantique</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Universal S.B.</td>
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<td>0</td>
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<td>0</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Koyo Dock K.K.</td>
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<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>11</strong></td>
<td><strong>26</strong></td>
<td><strong>36</strong></td>
<td><strong>40</strong></td>
<td><strong>10</strong></td>
<td><strong>0</strong></td>
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</tbody>
</table>

Source: Clarksons, September 2005
Seaborne LNG Trade Outlook

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Gas Carrier - LNG</td>
<td>13.0%</td>
<td>15.8%</td>
<td>20.0%</td>
<td>21.3%</td>
<td>13.8%</td>
<td>9.3%</td>
<td>8.0%</td>
<td>7.8%</td>
<td>7.3%</td>
<td>7.2%</td>
<td>7.3%</td>
</tr>
</tbody>
</table>

- **Long term** annual trade capacity growth forecast is based on seaborne LNG transport outlook.

- **Near term** includes speculative growth, or growth to support new initiatives, both reflected by the current orderbook.

LNG trade demand will likely be very strong over the next 10 years, with near term double digit annual growth.
LNG Fleet Capacity Growth 86%

Capacity (million cubic meters)

<table>
<thead>
<tr>
<th>Timeframe</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec 2004</td>
<td>20.69</td>
</tr>
<tr>
<td>Dec 2005</td>
<td>23.29</td>
</tr>
<tr>
<td>Dec 2006</td>
<td>26.99</td>
</tr>
<tr>
<td>Dec 2007</td>
<td>32.29</td>
</tr>
<tr>
<td>Dec 2008</td>
<td>39.29</td>
</tr>
<tr>
<td>Dec 2009</td>
<td>40.74</td>
</tr>
</tbody>
</table>

Clarksons – September 2005
LNG Fleet Forecast

Number of ships* - At Year End

- New Demand (cumulative)
- Replaced Ships (cumulative)
- Remaining Original Initial Fleet

Fleet Growth

- Y.E. 2004 Fleet = 176 Ships

Replacement Tonnage

Original Fleet Remaining

- New Demand will drive newbuilding deliveries
- Replacement tonnage will comprise only a very small share of the total newbuildings

Fleet will double in size by YE 2010 and grow another 35% by YE 2015

Based on ABS Shipping & Shipbuilding Outlook - Feb 2005 Forecast

* Considering average size steadily increases
Evolution of LNG Carrier Size

Cubic Meters

300,000 m³

200,000 m³

100,000 m³

0


100,000 m³

27,400

25,500

71,500

87,600

120,000

125,000

133,000

135,000

153,000

210/215

250,000

1964: Independent Prismatic Aluminum Cargo Tanks
1965: Independent Cylindrical Tanks
1969: First Membrane Ships
1973: First Moss Rosenberg Independent Spherical Tanks
1975: Ben Franklin & El Paso Kayser
1981: Finima
2007: 210/215
2009-2010: 250,000

2007: First Membrane Ships
2009-2010: 250,000
Larger LNG Carriers

- Technical Considerations
  - Structural Design
  - Terminal Compatibility
  - Propulsion Systems
Next Generation of LNG Ships Require Advanced Technology that Addresses the Transport System

- Propulsion Technology
- Containment System Technology
- Pump Tower Analysis
- Structural Integrity Technology
- Ship to Terminal Interface Technology
Total World LNG Fleet - Containment

Total Number of LNG ships - 185

Containment System Distribution

- Membrane GT & TGZ: 48%
- Independent Prismatic Tank Type B - IHI: 1%
- Conch: 2%
- Cylindrical: 1%
- Spherical Type B Kaeverner Moss: 48%

Total Number of LNG ships: 185
Current Order Book - 123

Moss -23

- 41 No 96, - 56 Mk III, - 3 CS-1

Membrane 100

81%  19%
GTT Membrane - No 96 Containment System

CORNER PART

- Invar thermal tension absorbed by raised edges deflection
- Secondary Membrane
- Invar Tube
- Double Hull

Invar thermal tension induced by cargo temperature

Primary Membrane

F: Maximum tensile load due to hull bending induced strain and thermal stresses
GTT MK III - Membrane Design
LNG Ships – Technical Issues

- **Size Increase** from 138,000 CbM to 250,000+ CbM
- **Re-gasification plants** on board
- **Ice strengthening** requirements for various trade routes
- **Fatigue life** up to 50 years
- **Offshore Terminal** discharging which exacerbates loads due to sloshing
Dual Fuel Electric Propulsion

(Diesel and Electric)

- 185 LNG ships in service
  - Steam turbine
- 123 LNG ships on order
  - 77 – Steam turbine
  - 45 - Diesel
    - 25-dual fuel diesel electric
    - 20 – slow speed diesel direct drive
Propulsion For Next Generation LNG Carriers

- **Alternative Propulsion**
  (Existing fleet is all steam turbine)
  - Propulsion efficiency
  - New technology developments
    - Dual fuel - Natural Gas & Fuel Oil
      - slow & medium speed diesels & gas turbines
      - shipboard re-liquefaction plants
Special Concerns for LNG

- Gasification of LNG
- Loss of Containment
- Liquid Spill on Deck
- Gas Release
- Disposal of Boil-off
- Fire and Explosion
- Over-pressure or Under-pressure
- Ship to Terminal Transfer of LNG
- Partial Loading
- Layout Constraints
Energy Bridge Regas Vessel

• Specially built LNG carrier fitted with onboard re-gasification equipment to transfer gas through a buoy, which is connected to a pipeline end manifold (PLEM) on the seafloor.
Offshore LNG Terminals/Concepts

Cabrillo Port
Offshore California

- Floating ship shaped hull

CGI

- Floating or fixed
- “Bishop process”
- Storage of LNG in Salt Caverns
Offshore LNG Terminals/Concepts

Compass Port
Gulf of Mexico

- Concrete Gravity Based (GBS)

Chevron-Texaco’s
Baja, California

- Concrete Gravity Based (GBS)
Offshore LNG Terminals/Concepts

Main Pass Energy Hub™
Gulf of Mexico

- Floating fixed platform
Closing Points

• First Transport of LNG by Sea was “Methane Pioneer” in 1959

• Today 185 LNG carriers transporting LNG from one region of the world to another…All of these vessels are “classed”

• Class societies serve as an independent third party verification agency

.....Safety & Compliance With Rules (Standards) are our Main Concern.....
Closing Points

• LNG Fleet is Expanding Rapidly to Handle Increased Demand
  – Larger ships
  – Changing propulsion systems
  – Changes in operations
  – Expanding owner base

• Offshore LNG Terminals – various concepts, Technical considerations

• Class provides Rules and Technical Guidance for LNG carriers and terminals

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