Taking advantages of membrane for small-scale LNG value chain

4th LNG Transport, Handling, Storage - Indonesia

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GTT in brief

▶ An engineering company with more than 50 years of experience in the design of the Membrane Cargo Containment Systems

▶ GTT is a public company listed on the Paris Stock Exchange
  ▶ A core shareholder, GDF Suez, the two other historical shareholders (Total and H&F) remaining in the capital
  ▶ Independent directors guarantee an autonomous governance of the company

▶ More than 100 projects\(^1\) (LNGCs, FSRUs, FLNGs, GSTs and “LNG as a fuel”) currently on order

▶ 370 highly qualified people\(^2\) keeping on addressing new market requirements, such as:
  ▶ Low BOR systems (particularly for spot)
  ▶ Intermediate filling levels (particularly for offshore)
  ▶ Small scale LNGCs (for retail LNG)
  ▶ LNG as a fuel tanks (for bunkering)

\(^1\) As of March 31\(^{st}\), 2014
\(^2\) As of December 31\(^{st}\), 2013
Our order book

Split by Product
- 86 LNGCs
- 10 FSRU/RV
- 3 FPSO
- 2 Onshore tanks
- 1 LNG fuelled ship

Order book by year of delivery

Split by Shipyard

Split by Technology

Source: GTT, March 31st, 2014
Note: excluding onshore storage tanks
Leadership position in offshore market with strong growth potential

<table>
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<tr>
<th>FSRU: GTT, the solution of choice</th>
<th>FPSO: the new frontier of the LNG World</th>
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<tr>
<td>▶ Growth driven by strong LNG demand which requires regasification solutions and alternative storage capacity</td>
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<td>▶ Easy, quick solution to address urgent energy needs in emerging markets</td>
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<td>▶ FSRUs require less time to build than onshore regasification terminals (about 2 years vs. 3.5 years)</td>
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<td>▶ FFSOs allow monetization of significant global stranded offshore gas reserves</td>
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<td>▶ Number of FLNG Projects multiply (between 10 and 15 projects)</td>
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<td>▶ Platform and/or Containment Systems can be designed to meet operational constraints</td>
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<td>▶ GTT’s membrane technology presents significant competitive advantages with deck space available for liquefaction equipment and competitive cost</td>
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▶ 100% of ordered FSRUs will be equipped with GTT’s technologies(1)
▶ Already 2 new orders received since January 2014
  ▶ Including the largest FSRU in the world with a capacity of 263,000 m³
▶ Three LNG FPSOs are currently on order for Petronas and Shell Prelude(1)
▶ These FPSOs will be fitted with GTT technology (100% GTT share)(2)

(1) As of March 31st, 2014
(2) Excludes vessel orders below 15,000 m³
FLNG orders

- **Shell Prelude FLNG**
  - EPCIC awarded to Technip-SHI
  - Storage tanks:
    - Two-row MkIII (220,000 m³ LNG)
    - Two-row MkIII (90,000 m³ LPG)

- **Petronas FLNG 1 (Kanowit)**
  - EPCIC awarded to Technip-DSME
  - Storage tanks:
    - Two-row NO96 (177,000 m³ LNG)

- **Petronas FLNG 2 (Rotan)**
  - EPCIC awarded to JGC-SHI
  - Storage tanks:
    - Two-row MarkIII (177,000 m³ LNG)
Small Scale LNG carriers: A Great Potential

- Small LNG carriers are crucial for supplying merchant vessels with LNG
- Currently, certain LNGCs are not suitable for all types of port facility
- Geographical potential:
  - Caribbean: distribution of LNG to the smallest islands is planned via the Dominican Republic or Puerto Rico.
  - China: Yangtze Delta, potential ECA in the Pearl River Delta region
  - India
  - Middle East/Mediterranean: small LNGCs could be needed to transport LNG from Israel to Turkey and Lebanon.
  - North America: coastal, rivers and lakes trades
  - South America: coastal and river trades
  - Southeast Asia: trades in the archipelagos

GTT membrane solutions are well adapted to small and mid scale applications
Small scale LNG shipping
Existing Small Scale membrane LNG carriers

Aman Sendai, Aman Bintulu and Aman Hakata
18,900 m³ (3 ships)

Trading between Malaysia and Japan

Surya Satsuma
22,500 m³

Trading between Indonesia and Japan
Membrane small – mid scale LNGCs

- Based on decades of safe LNGC operation
- Scaling to all ship sizes
- Cost effective, compact designs
- Best ratio of Cargo-volume vs Gross-tonnage
- Improved Harbour access
- Low operating & harbour costs

- Low Boil-Off rate
- Full cargo-range: any LNG quantity can be delivered
- Pressure-rise (up to 0.7 bar) can be implemented for more flexibility
Potential challenges

- **Costs of small scale LNG ships**

- **Minimum demand to justify investments and developments of small scale LNG chain (aggregation ?)**

- **Access**
  - deep water ?
  - air draft ?

- **Manning**

- **Several solutions:**
  - Increase the ship cargo capacity
  - Try milk-run operation
  - LNG barges
Volume optimization means Cost optimization

- Reload tariff based on ship size

![Graph showing estimated reloading terminal cost (€/MWh) for different bunker vessel sizes (m³ LNG). The x-axis represents the bunker vessel size in m³ LNG, and the y-axis represents the cost in €/MWh. The graph indicates that as the vessel size increases, the cost per m³ LNG decreases.]

- Which size makes it economical?
Argos project

- Argos is one of the largest independent players in the Western European oil and energy market
- Firstly developed a bunker ship with 4 x 300 m³ of LNG – Type C tanks
- Then developed the same bunker ship with GTT membrane tanks. The total LNG capacity increased to 1870 m³ (+55%)
Milk-run operations

- Based on the distances between the terminals & associated LNG demand, milk-run operations can be the most efficient:
  - Larger capacity
  - Reduced number of vessels
  - Easier to reconfigure when demand is increasing
  - “Design one, build many”

- But need for:
  - Access to many harbours
  - River trade
  - High manoeuvrability
  - High cargo capacity
  - Compact dimensions
  - Economic solutions
Small Scale LNG Carrier
15,000m³

**HULL:**
- \( L_{bp} = 117 \text{m} \)
- \( B = 22.5 \text{m} \)
- \( D = 15 \text{m} \)
- \( T_{des} = 6.4 \text{m} \)

**CARGO TANKS:**
- MarkIII CCS (270mm)
- Capacity = 15,000m³
- Number of tanks = 2
- BOR (LNG) = 0.280%V.p.d.

**POWER:**
- DF-DE
- Speed = 15.5kts
- Single screw / Fixed pitch
Shallow Draft LNG Carrier

- Modularity of membrane systems for more flexible and optimized solutions

- Tank shape customized to fit a particular hull

- A design of a small scale LNG Carrier with a shallow draft (lower than 5m) is then possible, with a reasonable cargo capacity (16,500 m³):
  - Regional waters to reach several islands
  - Coastal and river trade
  - Feeder for LNG bunkering

- Cargo capacity reduces the number of vessels required for the small scale LNG chain
Shallow Draft Small-Scale LNG Carrier
16,500m³

**HULL:**
- $L_{pp} = 126\,\text{m}$
- $B = 28\,\text{m}$
- $D = 11.7\,\text{m}$
- $T_{des} = 4.8\,\text{m}$

**CARGO TANKS:**
- MarkIII CCS (400mm)
- Capacity = 16,500m³
- Number of tanks = 2
- BOR (LNG) = 0.200%V.p.d.

**PROPULSION:**
- DF-DE
- Speed = 12.5kts
- Twin-screw / Fixed pitch
Shallow Draft Small-Scale LNG Carrier 16,500m³

- **Manoeuvring:**
  - Twin propeller solution with high-lift rudders
  - Forward thruster with high thrust for independent manoeuvring
  - “Crabbing” possible if reduced tug support

- **Visibility:**
  - Forward wheelhouse for better visibility

- **Operability:**
  - All filling application
Articulated Tug and Barge

- Commonly used in the USA
- Barges are loaded at the conventional LNG plants and then pushed to clients
- Empty barge is brought back with the same tug
- Crew remain the crew of a tug boat, not the one of an LNG carrier
2,200 m³ LNG bunker barge for USA (ATB type)

Main parameters:

- LOA: 64.6 m
- B: 14.8 m
- Draft: 2.6 m
- Tonnage: 1,440 GT
- Speed: up to 8 knots

Cargo:

- 2,200 m³ (100%)
- 2,066 m³ deliverable volume
- 4.5 hour full transfer time
- Capable of accepting return vapor from receiving vessel

Power for Operations:

- On board diesel generators for simplicity

- Single Cargo Tank: GTT Mark III Flex CCS
- Barge Design: Herbert Engineering Corp.
- CHS Design: CH-IV International
- AIP Received from ABS 21 March 2014
- Shipyard Level Cost Estimate Underway
Technical aspects

- **Sloshing in tanks is checked for all projects**
  - Analysis for small scale membrane LNG ships already performed
  - Indonesian routes considered
  - All filling acceptable for newbuilt ships

- **Multi-gas possibilities are possible with membrane**
  - Older vessels sailed with ethylene or LPG
  - No show-stoppers identified
  - GTT’s membrane technologies fully compliant
  - Approval In Principle from major Classification Societies

- **Boil-off gas management**
  - Increased thermal performance of insulation and higher pressure (700 mbar) allows for a reasonable autonomy in most of cases
  - LNG ships and FSRUs already delivered with such features
GTT is partnering with new yards for small LNG Carriers

- On January 8th 2014, Keppel Singmarine, specialised shipbuilding division of Keppel Offshore & Marine, and GTT signed a Technical Assistance and License Agreement for the design and construction of Liquefied Gas carriers.

- This partnership between Keppel Singmarine and GTT will benefit from the experience of both companies in providing optimized, innovative and high quality vessels to serve world demand in this field.
3

Storage solutions
Challenges

- Terminal costs

- Land availability
  - Onshore terminal?
  - Floating solution?

- Jetty availability

- Minimal water depth for LNG ships
Mid-scale FSRU – Example of 30,000m³

**HULL:**
- $L_{bp} = 124\text{m}$
- $B = 30\text{m}$
- $D = 20.5\text{m}$
- $T_{des} = 7.0\text{m}$

**CARGO TANKS:**
- NO96 CCS (530mm)
- Capacity = 30,000m³
- Number of tanks = 2

**FEATURES:**
- Side-by-side transfer
GTT land storage technology

- Two GTT onshore storage tanks are under construction
  - One tank for Indonesia (Sengkang LNG - 88,900 m³)
  - One tank for the Philippines (Pagbilao LNG - 130,000 m³)
Smaller tank size: Reduced umpumpable

- Example of a 40,000m³ LNG tank
  - 44m Tank diameter
  - 36m Overall height
  - Sump well configuration ⇒ only 500m³ dead stock
  - Increased prefabrication: only 4 months for Membrane system installation on site
  ⇒ Reduced footprint and tank height
Volume saving with membrane

- Extra LNG volume is between 10% to more than 35%
- Significant capacity difference for small & mid-scale tanks
GBS Solutions

- Storage in a breakwater

- Taking advantage of existing facilities: the storage function is combined with another function

- No land space required
GTT land storage technology

- GTT has optimized the design of the system since the first installation in 1981

- 33 membrane tanks using GTT technology have been constructed and are operational

- Based on the same principles as LNG Carriers, the recognized advantages cover:
  - Compactness of the design
  - High prefabrication
  - High local content
  - Better adapted to harsh seismic conditions
  - The fastest construction time
  - The cost savings
  - Easy to commission/decommission when demand is fluctuating (seasonal demand)
Conclusion

- Technologies are already available to offer several options to end-users for small and mid-scale LNG chain
- Proven systems are limiting risks
- Larger ship volume will reduce costs
- Demand aggregation and milk run operations are interesting options
- Strong constraints (environmental, space,...) so need for optimized and efficient storage solutions
- GTT is developing its network of shipyards for small scale LNG ships
Thank you for your attention