Floating CNG

A less expensive way to monetize offshore gas

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Regional gas transportation
INTRODUCTION
Compressed Natural Gas

Gas density
- Determined by pressure and temperature
- Maximum density ≠ maximum economics

Compression (compared to liquefaction);
- costs less
- requires less gas pre-treatment
- consumes less energy
- is proven offshore

<table>
<thead>
<tr>
<th></th>
<th>Pressure</th>
<th>Temp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>LNG</td>
<td>Ambient</td>
<td>-162 oC</td>
</tr>
<tr>
<td>CNG</td>
<td>275 BAR</td>
<td>Ambient</td>
</tr>
</tbody>
</table>
CNG land transport has a long history of safe operations

- Gas pipelines transport gas as CNG
- CNG is trucked in bulk in CNG “tube trailers”
- CNG fuels over 13 million motor vehicles
- CNG is a quickly growing segment of land-based gas transportation
- Transport of CNG by ship has not yet started
Evolution of Marine CNG

Columbia Gas (1965)

Patented Sea NG Bottle Ship (1997)

Original C25 = 75mmscf

New C20 = 75mmscf
Coselle CNG ships are offered by an Alliance of energy leaders
Teekay: 150 ships under management

6 Floating Storage Units (FSOs)
39 Shuttle Tankers
71 Crude Tankers

5 Floating Production Units (FPSOs)

Average Vessel Age 6.5 years

1 Excludes commercially managed vessels.
2 Based on owned shipping vessels (excluding FPSOs and FSOs), includes newbuildings.
Marubeni is a Japan-based trading firm and a FORTUNE Global 500 Company.
Leader in financing, investment and development of energy infrastructure
US$62 billion in assets with 4000+ employees
120 Offices in 67 countries
Leader in international trading and investment
Enbridge’s North American Pipeline System

ENBRIDGE INC.

- Owns world’s longest oil pipeline
- Transports 12% of U.S. daily crude imports.
- 80,000 km of oil and gas pipelines
- Operates deep water gas gathering systems
- Canada’s largest natural gas distribution company
- $40 billion in assets
The marine CNG transport process is simple, unlike LNG, no liquefaction or regasification is required.
CNG project investment is mostly for ships - moveable
more cost certainty (built in competitive, world class shipyard)
ships can be redeployed (reserves depleted, political situation . . .)
LNG project investment is mostly for onshore facilities – fixed
Investment stranded when reserves depleted
Many examples of LNG CAPEX substantially over budget
CNG – A large market
CNG ships add value for consumers

CNG connects natural gas reserves with regional energy markets
Marine CNG: ideally suited for the Mediterranean
DESIGN & ENGINEERING
Coselle is an efficient CNG container for ships

**Coselle**
Pipe OD = 168 mm
Pipe wall thickness = 6.3 mm
Coselle OD = 20.5 m

**Coselle net capacity**
4.2 mmscf ~ 120,000 scm ~ 82 t
4000 psi / 275 bar
80 oF / 27 oC
Pressure Bottles versus Coselles (equal volume)

≈

170 bottles

≈

6 Coselles

- Fewer containers
- Simpler manifold
- Fewer valves & fittings
- Higher safety
- Higher reliability
- Lower maintenance
- Lower costs
Coselle is a coiled pipeline used as a pressure vessel. The Coselle is a new application of existing, proven pipeline technology. **Coiled pipeline** for pipe-laying and **Coiled pipeline** for gas storage **Coselle**.
Coselle CNG ships exceed all safety requirements

Hazard identification and hazard operability studies

- **DNV:** Phase I, II and III Safety studies plus initial HAZID
- **ABS:** Final HAZOP and HAZID

ABS studies completed and approved include:

- Over-pressurization of cargo hold
- Impingement of gas cooled by JT effect
- Rapid dispersion of gas
- Jet fire
- Radiant heat
- Escape and evacuation
- FE modeling and analysis

Class Society conclusions

- **DNV:** “at least as safe as existing gas carriers”
- **ABS:** Full class approval for ship including Coselle containment and cargo system.
Ship and Coselle engineering: complete and approved
A decade of research, engineering and testing resulted in full approval at an operating pressure of 275 bar (4000 psi).

ABS APPROVED

Exceeded all ABS requirements. Critical fatigue testing exceeded requirements by 300% without failure (65,000 cycles).
Coselles form part of ship structure

- Results in a very strong ship
- Reduces ship steel (reduces cost)
- Creates an efficient ship shape (faster ship)
<table>
<thead>
<tr>
<th>Ship</th>
<th>C16</th>
<th>C20</th>
<th>C25</th>
<th>C30</th>
<th>C36</th>
<th>C42</th>
<th>C49</th>
<th>C84</th>
<th>C112</th>
<th>C128</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coselles</td>
<td>16</td>
<td>20</td>
<td>25</td>
<td>30</td>
<td>36</td>
<td>42</td>
<td>49</td>
<td>84</td>
<td>112</td>
<td>128</td>
</tr>
<tr>
<td>Net Capacity*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(million scf)</td>
<td>66</td>
<td>83</td>
<td>104</td>
<td>125</td>
<td>149</td>
<td>174</td>
<td>203</td>
<td>349</td>
<td>465</td>
<td>531</td>
</tr>
<tr>
<td>(million scm)</td>
<td>1.8</td>
<td>2.3</td>
<td>2.8</td>
<td>3.4</td>
<td>4.1</td>
<td>4.8</td>
<td>5.8</td>
<td>9.9</td>
<td>13.2</td>
<td>15</td>
</tr>
<tr>
<td>Length OA (m)</td>
<td>137</td>
<td>137</td>
<td>160</td>
<td>160</td>
<td>180</td>
<td>201</td>
<td>201</td>
<td>234</td>
<td>257</td>
<td>278</td>
</tr>
<tr>
<td>Breadth (m)</td>
<td>23.5</td>
<td>23.5</td>
<td>23.5</td>
<td>28.5</td>
<td>28.5</td>
<td>29.5</td>
<td>31.0</td>
<td>46.0</td>
<td>46.0</td>
<td>48.0</td>
</tr>
<tr>
<td>Loaded Draft (m)</td>
<td>7.3</td>
<td>7.5</td>
<td>8.0</td>
<td>7.9</td>
<td>8.2</td>
<td>8.3</td>
<td>8.8</td>
<td>8.7</td>
<td>10.5</td>
<td>10.5</td>
</tr>
</tbody>
</table>

* Net Capacity is net of heel gas and assumes lean gas at 27 oC
Coselle creates an efficient gas ship

Classified as an

☐ A1 Compressed Natural Gas Carrier
LOADING & OFFLOADING
Jetty Loading Facility Overview

1. Inlet gas via pipeline
2. Inlet separator
3. Knockout drum
4. Flare stack
5. Regen gas heater
6. Gas compressors
7. Sea water supply tank
8. Produced liquids tank
9. Firewater pumps/jacks
10. Liquids separator
11. Regen cooler/separator
12. Dehydration absorbers
13. Sewage/potable water
14. Control/warehouse
15. Instrument air
16. Mechanical
17. Jetty with pipeline
18. Midship Loading Arms
19. C36 class CNG ship
Jetty Discharge Facility Overview

1. C36 class CNG ship
2. Midship Loading Arms
3. Jetty with pipeline
4. Inlet separator
5. Knockout drum
6. Flare stack
7. Gas compressors
8. Coolers
9. Fuel gas scrubber
10. Instrument air
11. Potable water
12. Gas discharge pipeline
Offshore loading options

Shallow water
SAL

Moderate depths
STL

Deepwater tandem
FLOATING CNG
Production Rate: 350 mmMscf/d = 2.5 Mtpa ≈ 10 mil m³/d

- **CNG shuttle ships**
  - 350 mmMscf capacity
  - 84 Coselles per ship

- **CNG Transfer tandem system**

- **Gas FPSO (FCNG)**
  - processing and compression
  - mooring system (turret)
  - buffer CNG storage

- **Reservoir gas**
Coselle CNG shuttle ships (C84)
$86,000 / day / ship

Gas FPSO (FCNG)
$240,000 / day

<table>
<thead>
<tr>
<th>Distance (km)</th>
<th># of C84 Ships</th>
<th>Tariff $/mmBtu</th>
<th>Capital $/tpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>$0.70</td>
<td>244</td>
</tr>
<tr>
<td>350</td>
<td>3</td>
<td>$1.50</td>
<td>496</td>
</tr>
<tr>
<td>700</td>
<td>4</td>
<td>$1.75</td>
<td>580</td>
</tr>
<tr>
<td>1050</td>
<td>5</td>
<td>$2.00</td>
<td>664</td>
</tr>
<tr>
<td>1400</td>
<td>6</td>
<td>$2.25</td>
<td>748</td>
</tr>
</tbody>
</table>
Floating CNG (FCNG) Vessel with 84 Storage Coselles
CNG is a simpler and lower cost way to monetize offshore gas

An FCNG vessel is a traditional gas FPSO

Instead of compressing gas into a pipeline compress gas into a ship

Compared to Floating LNG, Floating CNG

- is more tolerant to turn-downs and shut-downs
- is more tolerant to CO2, mercury and other contaminates
- transfer operations in open ocean conditions is relatively simple
- does not require large gas storage on the production unit (safer)
- can be used to transport associated gas or flared gas

Can be scaled to lower production by reducing number or size of ships.

Ships and FCNG vessel can be redeployed at end of field life

Coselle ships provide safe and efficient CNG transport

The Coselle CNG ship is approved and ready for construction

World class companies will own and operate the Coselle CNG ships

Coselle ships could be in service within 28 months of contract
Conclusions

No regulatory risk
ABS has approved the ships (full approval)

Cost and schedule risk is low
The ships will be constructed in major shipyards, reducing cost and schedule risk

80% of cost is the ships, 20% is the onshore facilities

Potential Benefit to Cyprus
Near Term: CNG ships could be used to ship gas to Cyprus (say from Israel)

Longer Term: once Cypriot gas is available the same CNG ships could be used to transport gas from Cyprus to Europe

Compliments LNG plans
LNG for distant markets, CNG for near markets
MARINE CNG

Half the density, twice the value (regional markets)
Sea NG Corporation

Suite 750, 101-6th Avenue SW
Calgary, Alberta, T2P 3P4
Canada

online tariff calculator:
www.sea-ng.com

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