Floating LNG – Monetization of Stranded Gas

AIChE, LDM

Zoetermeer, 25 September 2012
Introduction to CB&I
Stranded Gas Occurrences
Gas prices
FLNG units
FLNG advantages
Present FLNG projects and prospects
Commercial analysis
Summary
CB&I’s History

CB&I known for Storage Tanks and Terminals

[Image of storage tanks and terminals]
CB&I Today – The Company

3000 Contracts in 65 Countries
- Offshore
- Pipelines
- Refining
- Petrochemicals
- Natural Gas Processing
  - LNG
- Steel Plate Structures

CB&I believes in Strategic Relationships

Repeat Customers
- 82 Customers with > 5 Projects
- 32 Customers with > 10 Projects

Engineering Solutions . . . Delivering Results
• Technology and EPFC company
• Currently ranked number 6 among ENR’s Top 20 Contractors in Petroleum
• 2011 revenue of more than $4.6 billion with backlog today over $10 billion
• More than 18,000 employees worldwide
• Full scope services
• Total company commitment to safety
Upstream

- Oil & Gas Production
  - Onshore
  - Offshore
    - Topsides for Fixed & FPSOs
- Gas Processing
- Pipelines
  - Onshore
Offshore Capability

- Over 50 Topsides since 1990
- Fixed Platform, FPSO, TLP, Spar
- Weight range: 250t – 30,000t
- Global Experience
  - North Sea, Brazil, Australia, GoM, West Africa, SE Asia, Middle East
- Range of Platform Types
  - Accommodation, NUIs, Wellhead, Compression, HP/HT, Integrated Decks, Float over, Heavy Lift
- Services Offered:
  - Concept, FEED, Engineering, Procurement, Construction Support, EPF, Technical Training
Small Topsides (<2000t)
- ExxonMobil - Sable 2
- BG - Minerva
- Elf - Elgin/Franklin

Medium Topsides (>2000t <10,000t)
- Talisman – Montrose BLP
- BP / HHI – Clair Ridge LQ
- BP / Aker – Skarv FPSO
- BP – Bruce Phase 2
- Texaco - Captain B
- Statoil - Huldra

Large Topsides (>10,000t)
- Nexen – Golden Eagle
- Eni Norge / HHI - Goliat
- Nexen - Buzzard
- Petrobras / Modec – Tupi
- Petrobras / Modec – Guara
- Four FLNG FEEDs executed: Shell Kudu, Hoegh LNG, In-house FLNG, Petronas FLNG-2
- More than 400,000 FLNG manhours spent…
- Ongoing work with Hoegh LNG and Petronas FEED
Client: Shell Global Solutions
Project: Kudu FLNG Unit
Location: Offshore Namibia
Project Services: BE, CE, FEED Project
TIC: $1 Billion +
Contract Value: Confidential
Start/Complete: FEED completed 2002
Summary:
- LNG 5 MTPA
- LPG + Condensates

Highlight:
- Shell MR Technology
- Integrated team for project execution in CB&I offices
- Babcock (Armstrong) responsible for hull engineering
- Similar dimensions as Shell Prelude FLNG
<table>
<thead>
<tr>
<th>Client:</th>
<th>Petronas-MISC</th>
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</thead>
<tbody>
<tr>
<td>Project:</td>
<td>FLNG-2, Rotan Field</td>
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<tr>
<td>Location:</td>
<td>Offshore Sabah</td>
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<tr>
<td>Project Services:</td>
<td>FEED Process Topsides</td>
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<tr>
<td>TIC:</td>
<td>$1 Billion +</td>
</tr>
<tr>
<td>Contract Value:</td>
<td>Confidential</td>
</tr>
<tr>
<td>Start/ Complete:</td>
<td>June 2012- June 2013</td>
</tr>
<tr>
<td>Summary:</td>
<td>25,000 tons topsides</td>
</tr>
<tr>
<td></td>
<td>275 mm³scf/day gas</td>
</tr>
<tr>
<td></td>
<td>1500 m water depth</td>
</tr>
<tr>
<td>Highlight:</td>
<td>Consortium with MODEC, IHI and Toyo Engineering</td>
</tr>
<tr>
<td></td>
<td>Dual FEED competition</td>
</tr>
<tr>
<td></td>
<td>Binding EPCI offer</td>
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</table>
World’s Stranded Gas Reserves

- Proven reserves: more gas than oil in the world
- Proven conventional gas reserves: 5,500 TCF or 75 years of today’s consumption
- Offshore locations with 2 to 5 TCF recoverable gas reserves: 150 – 300
- Half of proven gas reserves is stranded, of which half is offshore
- Most recent locations: East Africa, Offshore Mediterranean
LNG Markets - Firm and Flexible

Firm
- Markets which have to have the LNG supply and will pay the price needed to secure cargoes
- Asia, southern Europe (Turkey, Spain, southern France, Portugal), Latin America, Caribbean

Flexible
- Markets with alternative pipeline gas supplies where price will determine whether LNG is imported
- USA (Gulf of Mexico, West Coast), UK, Belgium, Netherlands
Total LNG Demand in firm Markets

Source: Andy Flower
## LNG Imports by Country (MTPA)

<table>
<thead>
<tr>
<th>Country</th>
<th>Imports (MTPA)</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>Japan</td>
<td>70.6</td>
<td>Firm</td>
</tr>
<tr>
<td>S Korea</td>
<td>34.1</td>
<td>Firm</td>
</tr>
<tr>
<td>Spain</td>
<td>20.5</td>
<td>Firm</td>
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<tr>
<td>UK</td>
<td>14.2</td>
<td></td>
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<tr>
<td>Taiwan</td>
<td>11.6</td>
<td>Firm</td>
</tr>
<tr>
<td>France</td>
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<tr>
<td>China</td>
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<td>Firm</td>
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<tr>
<td>India</td>
<td>9.3</td>
<td>Firm</td>
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<tr>
<td>US</td>
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<tr>
<td>Italy</td>
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<td>Turkey</td>
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<td>Firm</td>
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<td>Belgium</td>
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</tr>
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<td>Mexico</td>
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<td></td>
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<td>Portugal</td>
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<td></td>
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<td>Kuwait</td>
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<td>Brazil</td>
<td>2.0</td>
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<tr>
<td>Canada</td>
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<td>Argentina</td>
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<td>Greece</td>
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<td>Dominican Rep.</td>
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<td>Puerto Rico</td>
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<tr>
<td>UAE</td>
<td>0.1</td>
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</tr>
</tbody>
</table>

**Total Imports:** 223.8

**Sources:** Waterborne LNG Reports, US DOE, PFC Energy

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**LNG imports in East Asia:**
- 123 million tons
- 55% of total LNG demand
- 7.5% more than 2010
- Japan abolishing nuclear power in near future
- China increasing demand – approximately 30 MTPA in 5 years time
Many longer term contracts in Japan/Korea - price examples of 12 to 14 US$

Highly attractive market in East Asia

With a value chain cost of 6 - 7 US$/MMBTU, the East Asia market is very attractive

USA spot market prices are low – large supply from shale gas
FLNG is the gas monetization solution for stranded gas
Lessons from fast developing FSRU market

- FSRU market has boomed in the past 2 years
- Presently 11 FSRU units operating, 3 under development and 14 units proposed
- Key players are Excellerate, Golar and Hoegh
- Features include short lead time (record 12 months), low CAPEX, simple civil works.
- Typical Floating unit investment: US$ 300 million
One integrated facility with

- Hull with accommodation and storage tanks
- Turret & mooring
- Topsides with process systems
- Power plant & utilities
- Transport and escape facilities
Onshore LNG Example - Peru LNG

- Pampa Melchorita 170km South of Lima
- 4.45 MMT/yr LNG Export
- APCI Liquefaction Technology

- 2 x 130,000m³ Single Containment Tanks
- 1300m Jetty + Breakwater
- Plant Utilities & Offsites
Floating LNG benefits

- Solution for associated gas for remote and ultra deepwater fields
- Possibilities to monetize smaller reservoirs
- Solution for labor availability constraints
- Sovereign stability
- Smaller environmental footprint
- Remote from population
- No temporary infrastructure required
- Asset security and insurability
- More controlled construction
- Eliminate pipeline routing constraints
- Integrated facilities, no need for loading quays and separate tanks
- No harbour traffic
- Competitive in price
Floating LNG challenges

Technical Design Challenges

- Safety - limited footprint – survivability
- Survival condition/Environmental loads
- Dynamic behavior
- Maintenance / lifting & sea transport
- Combining FPSO marine & LNG practices
- Weight and dimensions

Project challenges

- Business model
- Supply chain & Partnerships
- Risk mitigation
- Offshore logistics
- Product logistics

First FLNG under construction for Shell

- Length: 474 meter
- Width: 74 meter
- Draft: 17 meter
- Displacement: 600,000 ton
- Production: 5 MTPA LNG & LPG & Cond
- Turret: 30 m Dia, 105 m high
- Storage:
  - 220,000 m3 LNG
  - 125,000 m3 Condensate
  - 90,000 m3 LPG
FLNG project challenges
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Facility Complexity

10,000  50,000  100,000

Topsides Weight (tons)

Oil FPSO versus a Floating LNG facility

Large Scale FLNG

Medium scale FLNG

LPG FPSO's

Crude & Gas FPSO's

Crude oil FPSO's

FLNG facility – scaling up….
Product logistics

**Production profile**

- **Pre-treatment**
  - IN: 278 MMSCFD FEED GAS
  - OUT: 13 t/h CO₂, H₂O

- **Liquefaction**
  - IN: 19 MMSCFD (7% of feed)
  - OUT: 1.95 MTA LNG

- **Fractionation**
  - IN: 4,000 bpd LPG
  - OUT: 10,000 bpd LPG

- **End Flash + Boil-off**
  - OUT: 19 MMSCFD FUEL GAS
Considerations for offshore environment

- FEED gas via riser system
- Concurrent off loading (LNG, LPG, NGL)
- Vessel suitability & availability
- Safety
- Point of Delivery
- Metering of Product
- New technology / Novel applications
Product Logistics - Offloading Options

Side-by-side

Tandem

Remote SPM

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Product Logistics - LNG Offloading Options

Side-by-side

Tandem

Loading Arms

Hoses
Condensate and Oil transfer
- Proven technology
- Side by side & Tandem systems
- CALM buoy systems
- Fully tested and Certified components

LPG transfer
- Side by side = Proven technology
- Tandem systems possible
- CALM buoy systems possible
- Fully tested and Certified components

LNG transfer
- Working systems
- Concrete proposals
- Fully tested and Certified components
<table>
<thead>
<tr>
<th>Operator</th>
<th>Name</th>
<th>Location</th>
<th>LNG Prod (MTPA)</th>
<th>Status</th>
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<tr>
<td>Shell</td>
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<td>Petronas</td>
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<td>Offshore Malaysia</td>
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<td>FEED</td>
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<tr>
<td>Woodside / Shell</td>
<td>Sunrise</td>
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</table>
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FLNG Initiatives versus markets

- FLNG units located relatively close to the market
- East Asia market at 3,000 – 3,500 miles distance

9 FLNG Units
Vary a lot and are pending on field of employment, feed gas composition and product specifications

Mostly new built units on the drawing boards; initiatives emerging for conversion FLNGs

Shell Prelude is producing 5.2 MTPA of product; Costs in the press: EPC contract 6 BUSD, 10 BUSD for overall project ....

Petrobras Santos FLNG processes 12 – 14 MM3 gas and produces 2.5 MTPA LNG, “x” MTPA NGL’s. Costs in the press vary from respectively 3.3 to 3.8 and 4.8 BUSD

Source: Upstream
Cost Example

- 1.6 MTPA (1.6 TCF)
- Deepwater (floating)
- Open Ocean
- LNG Tanker Based
- LNG Stored in Hull
- < 1.5 mol% CO2
## Subsea Costs

- Water depth
- Gas flowrate
- Number of wells
- Number of risers
- Intervention

### Production Cost

<table>
<thead>
<tr>
<th>OPTION</th>
<th>PRODUCTION COST $/MMBTU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Currently Re-injected</td>
<td>-1.0 ?</td>
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<tr>
<td>Currently Flared (Associated Gas)</td>
<td>Zero ?</td>
</tr>
<tr>
<td>Shallow Water Production</td>
<td>1.0 – 2.0</td>
</tr>
<tr>
<td>Deep Water Production</td>
<td>5.0 – 7.0</td>
</tr>
</tbody>
</table>

Source: Brian Songhurst

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Overall Costs

**Adding Value at Every Step**

- **Gas Production**: $1.5/MMBTU
- **LNG Production (LPG Production)**: $2.8/MMBTU
- **LNG Shipping**: $1/MMBTU
- **Storage/Regas**: $1/MMBTU

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Known risk

Unknown risk

Expect the unexpected!
Commercial Risk

Key success factors FLNG unit

- Predictability
- Reliability
- Acceptance of technologies
- Interface management
- Risk sharing
FLNGs have become real recently – Shell Prelude and Petronas FLNG-1 are trailblazer projects.

There are solid reasons to select FLNGs as an alternative for onshore LNG plants.

Most FLNG initiatives are located relatively close to the largest demand market in East Asia.

FLNG CAPEX costs seems to be competitive to onshore LNG plants.

There are limits to the production capacity of FLNG units – Prelude is currently the largest unit with a production of 5.2 MTPA.

FLNG is having a Future....!
Thank You For Your Attention
Jleo@cbi.com