Part 3 LNG plant construction principles

- 3.1 Construction methods
- 3.2 Typical construction schedule
- 3.3 LNG plant cost distribution
- 3.4 Typical LNG plant quantities
Construction methods

Stick building

- Most common LNG onshore plant construction method, but requires
  - Availability of labour at low cost
  - Suitable site, without large site preparation works
  - Suitable climatic conditions for out door works year around
  - Large construction and plant areas

- Stick building enables
  - Low cost construction
  - Schedule flexibility
  - Use large unskilled work forces
  - High local content
Construction Methods

Modular Construction

- Modular is becoming a more common LNG onshore plant construction method, but is mainly used when
  - local labour cost is high
  - site preparation is very significant
  - climatic conditions are challenging
  - restrictions on use and availability of land
- If location is suitable and cost competitive resources are available than stick built is the preferred option, due to lowest cost
- Modular enables
  - reduction of plant foot print, only if water cooled
  - reduction of construction area
  - onsite man-power by about one third and shortens man-power peak period
  - superior fabrication conditions, normally providing higher efficiency and quality
  - some delay of early works

Modular LNG in Australia

- 3 trains of 5 MTPA
- 250,000 tons of modules
Construction Methods

Barge concept

• Snøhvit is the only barge type plant constructed and was selected due to
  - plant footprint had to be reduced, due to availability of land on the island
  - limited laydown and camp areas for construction on the island
  - arctic working environment would give low productivity
  - high cost of labour
  - limited availability of labour
  - maximising mechanical completion and pre-commissioning in controlled environment
  - work force on site about 30 to 40% third of a stick built plant

Snøhvit LNG plant

Single train: 4.3 MTPA
Size of barge:
Construction time: 60 months
Peak man-power onsite: 3500
Construction Methods

Floating LNG

- Floating LNG is fully islanded and self-sufficient LNG plant
- The first one is under construction in Korea by Shell, but for offshore application
- However, such concept can have both offshore and nearshore applications
- Nearshore applications are most likely
  - in remote areas with difficult access
  - in arctic conditions, where extreme winterization measures are needed
  - in very sensitive environmental areas
  - where possibilities to have large work force on land is very challenging
  - if geotechnical conditions are challenging
  - when minimum on-site activities is required

Statoil’s floating LNG concept

Single train: 3 to 4 MTPA
L x B = 425 m x 65 m
16 large modules weighing 1500 to 5500 tons
Typical modularized plant schedule

YEAR 1
- PREE FEED & FEED

YEAR 2
- DETAIL DESIGN
- PROCUREMENT
- SUBCONTRACTING
- PREFABRICATION
- MODULE FABRICATION & TRANSPORT
- LNG TANK CONSTRUCTION
- JETTY TOPSIDE

YEAR 3
- LNG TRAIN
- PFAB CAMP
- CONSTRUCTION VILLAGE
- TEMPORARY FACILITIES
- PERMANENT VILLAGE
- UTILITIES
- STE PREPARATION
- MOF
- LNG JETTY

YEAR 4
- YEAR 5
- YEAR 6
- RFSU Train 1
- First LNG cargo
- COMMISSIONING
- START UP
**Example large modular LNG plant cost distribution**

<table>
<thead>
<tr>
<th>Description</th>
<th>% of EPC CAPEX</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment (static and rotating equipment)</td>
<td>12 to 16</td>
</tr>
<tr>
<td>Bulk materials (steel, piping, electrical, instrumentation, insulation etc.)</td>
<td>10 to 14</td>
</tr>
<tr>
<td>Material related (freight, spares, vendor services, module transportation etc.)</td>
<td>6 to 8</td>
</tr>
<tr>
<td>Subcontracts (site preparation, foundations, modules, tanks, jetties etc.)</td>
<td>45 to 50</td>
</tr>
<tr>
<td>Construction services (construction management, camp, temp. facilities etc.)</td>
<td>5 to 7</td>
</tr>
<tr>
<td>Other (engineering, insurances, project completion, commissioning etc.)</td>
<td>13 to 17</td>
</tr>
</tbody>
</table>

This is an example distributions will vary depending upon site conditions, plant lay-out, number of trains, gas liquefaction technology, cooling medium etc.
Example large modular LNG plant quantities

<table>
<thead>
<tr>
<th>Description</th>
<th>Pre assembled units</th>
<th>Pre assembled racks</th>
<th>Vertical assembled units</th>
<th>Dressed vessels</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Qty</td>
<td>Total Modularized weight (tonnes)</td>
<td>Qty</td>
<td>Total Modularized weight (tonnes)</td>
<td>Qty</td>
</tr>
<tr>
<td>LNG trains</td>
<td>26</td>
<td>42,000</td>
<td>16</td>
<td>11,000</td>
<td>-</td>
</tr>
<tr>
<td>Utilities and offsites</td>
<td>8</td>
<td>16,000</td>
<td>0</td>
<td>0</td>
<td>13</td>
</tr>
<tr>
<td>Interconnecting piperacks</td>
<td>-</td>
<td>-</td>
<td>138</td>
<td>31,000</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>34</td>
<td>58,000</td>
<td>154</td>
<td>42,000</td>
<td>13</td>
</tr>
</tbody>
</table>

- Large equipment items/packages either included in modules or as separate packages are 500 to 600 items
- Module steel weight: 55 Ktonnes
- Module piping weight: 32 Ktonnes

This is an example and quantities and weight will vary depending upon site conditions, plant lay-out, number of trains, gas liquefaction technology, cooling medium etc.
Example civil work quantities

<table>
<thead>
<tr>
<th>Description</th>
<th>Length (km)</th>
<th>Area (10^3 m^2)</th>
<th>Volume (10^6 m^3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant size</td>
<td>2.5 x 1.5</td>
<td>3.75</td>
<td></td>
</tr>
<tr>
<td>Grup up flora</td>
<td></td>
<td>3.75</td>
<td></td>
</tr>
<tr>
<td>Remove top soil</td>
<td></td>
<td></td>
<td>1.9</td>
</tr>
<tr>
<td>Excavation granular</td>
<td></td>
<td></td>
<td>2.0</td>
</tr>
<tr>
<td>Rock excavation</td>
<td></td>
<td></td>
<td>4.0</td>
</tr>
<tr>
<td>Filling and grading</td>
<td></td>
<td></td>
<td>6.0</td>
</tr>
<tr>
<td>Roads</td>
<td>~ 120 km</td>
<td></td>
<td>160</td>
</tr>
<tr>
<td>Fencing</td>
<td>~ 20 km</td>
<td>80 (double fence)</td>
<td></td>
</tr>
</tbody>
</table>

This is an example and quantities and weight will vary depending upon site conditions, plant lay-out, number of trains, gas liquefaction technology, cooling medium etc.
## Typical plant administration and support buildings

<table>
<thead>
<tr>
<th>Description</th>
<th>No. of stories</th>
<th>Floor area (m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Administration building</td>
<td>2</td>
<td>2000</td>
</tr>
<tr>
<td>Central locker room and showers</td>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>Canteen and kitchen</td>
<td>1</td>
<td>1000</td>
</tr>
<tr>
<td>Medical center and ambulance bay</td>
<td>1</td>
<td>200</td>
</tr>
<tr>
<td>Fire station</td>
<td>1</td>
<td>250</td>
</tr>
<tr>
<td>Workshop</td>
<td>1</td>
<td>2700</td>
</tr>
<tr>
<td>Warehouse</td>
<td>1</td>
<td>2700</td>
</tr>
<tr>
<td>Laboratory</td>
<td>1</td>
<td>375</td>
</tr>
<tr>
<td>Main control building</td>
<td>1</td>
<td>1200</td>
</tr>
<tr>
<td>Security building/guard house</td>
<td>1</td>
<td>400</td>
</tr>
<tr>
<td>Admin. Area substation</td>
<td>1</td>
<td>450</td>
</tr>
<tr>
<td>Visitor / Training centre</td>
<td>1</td>
<td>800</td>
</tr>
</tbody>
</table>

This is an example and quantities and weight will vary depending upon site conditions, plant lay-out and authority requirements.
There's never been a better time for good ideas

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