Offshore LNG
Revisiting the Concept

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The end of the era of high oil prices stalled investment but many lessons from this period are useful in the new environment.

FIDs for new capacity by year:

- **First Generation LNG**: 28 Mtpa
- **Mid-scale Chinese LNG**
- **Yamal LNG**

3% – 5% supply growth
First FLNG Generation
Lessons learnt

- Lessons of First Generation FLNG
  - FLNG feasibility is demonstrated
  - Minimize on-deck integration of modules including topside /hull interfaces
  - Consider specialized yards for topsides
  - Increase revenue per m²

- Lessons of Yamal LNG
  - Modularization on a large scale enables cost and schedule certainty in extreme locations
  - Large modules and FLNG type design would have advantages
  - Minimize cable pulling and other integration activities at site
Potential sources of cost reductions

**Process and plant design**
- Process simplification. Reduce the number of equipment items
- Use of larger and/or more compact equipment
- Layout optimization
- Improved reliability
- Greater efficiency / smaller utilities/ lower OPEX

**Procurement**
- Work with suppliers to review opportunities
- Design basis cooperation; Codes and standards; Documentation; QC

**Construction**
- Prefabrication and modularization including large modules

**Project execution**
- EPC contractual terms : risk sharing
- Qualification of high value subcontractors
- Modularization including mega-modules
- Digitalization
The FLNG market – opportunities at both ends

Meeting the challenge of producing competitively priced LNG offshore

<table>
<thead>
<tr>
<th>0.5 - 1.5 / 2 Mtpa</th>
<th>2 – 5 Mtpa</th>
<th>5 - 8 Mtpa</th>
</tr>
</thead>
<tbody>
<tr>
<td>“MAG” Monetization of associated gas – small-scale</td>
<td>“Conventional”</td>
<td>“NewWave” Intensified processes with LNG production increased</td>
</tr>
</tbody>
</table>

Economies of feedstock – associated gas is a cost/constraint to the operator when reinjected or flared.

Economies of scale – gas is produced from large productive reservoirs often in deep water.

Combined with an array of design, execution and construction features common to all
DMR liquefaction technology:
- Highest production intensity & lowest emissions of any process,
- Design and operational feedback from several projects,
- MR liquid inventory, confined to exchangers by process design; MR liquid piping is welded

**Dashed Refrigerant, Hybrid Cooling Principle**

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## Hybrid Cooling Benefits (*)

<table>
<thead>
<tr>
<th></th>
<th>Case 1</th>
<th>Case 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cooling medium</strong></td>
<td>Air Coolers</td>
<td>Hybrid (Air Coolers + SW)</td>
</tr>
<tr>
<td><strong>Ambient conditions</strong></td>
<td>Air: 28 + 1°C</td>
<td>Air: 28 + 1°C</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SW: 21°C</td>
</tr>
<tr>
<td><strong>Liquefaction capacity (MTPA)</strong></td>
<td>2.1</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>MM size: L x W x H (m)</strong></td>
<td>70 x 64 x 40</td>
<td>59 x 64 x 40</td>
</tr>
<tr>
<td><strong>MM weight (t)</strong></td>
<td>24 300</td>
<td>23 400</td>
</tr>
<tr>
<td><strong>SW flow rate (m3/h)</strong></td>
<td>N/A</td>
<td>6 300</td>
</tr>
<tr>
<td><strong>SW collector design</strong></td>
<td>N/A</td>
<td>36”</td>
</tr>
<tr>
<td><strong>Cost index</strong></td>
<td><strong>100</strong></td>
<td><strong>87</strong></td>
</tr>
</tbody>
</table>

(*) Based on same compressors Gas Turbine Drivers
Hybrid Cooling benefits summary

WMR condensation with SW lowers condensing temperature and increases LNG production
- Use of high-grade material with SW is justified by gain in production.
- If required, with a small production penalty, fresh CCW can be used

The use of AFCs minimizes interfaces with hull and simplifies integration
- Secures schedule as no water is required for compressor tests
- Commissioning of the liquefaction module at grade can include full recycle of compressors

Consideration can be given to SW supply and return systems dedicated to each liquefaction module
- Hull penetrations can be avoided
- No pipe-runs on the main deck.

Commissioning at yard maximized.

Overlap between construction and commissioning at quay to reduce carry-over risks.

In operation, compressor recycle can allow survival of a loss of cooling water

**Reduced hull/topsides interfaces, increased LNG production, reduced CapEx and secured schedule**
MegaModule™ design

- Operationally self-standing modules
  - Integrated construction completion and PC&C activities minimizing COW risks
  - Simplified pre-commissioning & commissioning sequence

- Overall quantities reduced for a given LNG throughput
  - Savings on supply quantities
  - Savings on fabrication costs
  - Man-hours savings
  - Shortened planning, limited integration
MegaModule™ design benefits on dimensions and weights

Separate yards for hull construction and topsides fabrication and integration
- Opening competition
- Savings in material quantities
- Cost and integration time savings

✓ Maximizing modules construction completion at ground level
✓ Skid-deck installation
✓ Minimize carryover work and integration
✓ Reduce Construction cost
✓ Secure schedule, provides float for Hull
  - Pre-commissioning / Full commissioning at yard
  - Maximize use of available real estate at yards
Maximized Onshore Pre-commissioning & Commissioning
MegaModule™ installation technique: jacking & skidding
TechnipFMC concept - costs can be improved in many ways

Current studies confirm a 30-40% cost reduction

<< 900$/tpa LNG Incl. Pretreatment & Utilities

- Quayside completion of larger functional modules
- Intensification
  - Processes
  - Machinery
  - Exchangers
  - Cooling
  - Separators
- Simplification
  - Standards & specs
  - Minimum interfaces
- Productivity
  - Scale
  - Availability
  - Subsea processing
  - Digitalization
7.5 MPTA FLNG design fits within industry references

Topside weight & Hull size: similar to largest FLNG, thanks to innovative Topsides design

Project Cost and Schedule significantly improved
Thank you for your attention

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