

The Technical & Practical challenges of FLNG

SUT Evening Technical Meeting: "On the Fringes of FLNG", Perth 19/08/2015

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Agenda

- Introduction
- Acknowledgement to Shell Australia
- Lloyd's Register and FLNG
- FLNG Challenges

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Lloyds Register's role in FLNG

- Prelude world's first Floating LNG Project.
 - FEED design review at generic & project specific concept stage,
 - Verification, Certification, Classification and Validation services.
- FLNG Rules annually reviewed latest revision July 2015.
- Supporting publications including:
 - Surveys by ROV,
 - Risk based inspection for hull structures,
 - Risk based analysis for cryogenics spills,
 - Fire loading and protection,
 - Calculation of probabilistic explosion loads,
 - Technology Qualification.



Image courtesy of Shell Australia

FLNG Overview

Access stranded gas, using:

- Floating offshore or near shore structure permanently moored
- Subsea wells, via flowlines and risers (or other incoming supply)
- Fractionation and cleaning modules
- Liquefaction (refrigeration)
- Storage LNG, LPGs and condensate (oil)
- Offloading tandem or side by side



Image courtesy of Shell Australia

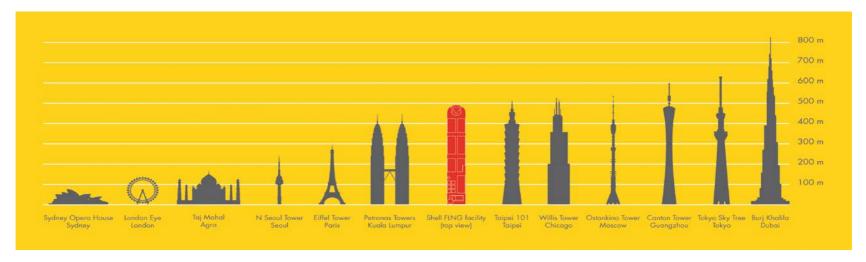
The Challenge

Combine new technologies, codes, standards and practice from three industries.

- Marine LNGCs
- Floating Offshore Installations
- Land based liquefaction Hull Helideck Complex supply chain Pre-treatment Incine Handling ration equipm. **Utilities** Liquefaction Significant new IP Instrum. Demin. Power Refrigerat Refrigerat. Accommowater system make-up system removal dation system Ψ Λ Flare/ Fuel Gas Service Fire Feed Lique-Harsh environment dehydra-HVAC blow End water faction compr. system down system flash Process Temp./ Potable Drain Fractio-Condens Inlet Life Chemicals heat stabil. facilities water water systems nation boats generat. Waste Storage Sea Turret/ water mooring treatment loading 9 Main systems of a LNG FPSO Subsea, wells

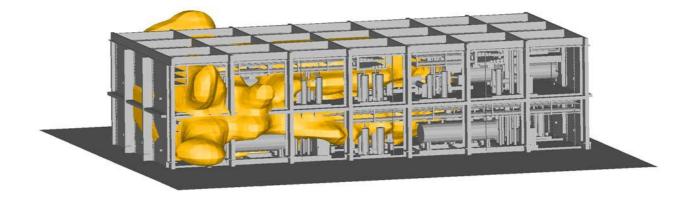
FLNG Design Issues

- New concept => risks associated with:
 - Process (restricted footprint versus land plant)
 - Vessel motions effect on process plant
 - Process plant reliability (limited line pack available)
 - Storage of large quantities of process chemicals
 - Potential production and storage of multiple liquid and gas types
 - Managing Cryogenic fluids in proximity to large, critical hull structures



FLNG Design Issues

- Sloshing (dynamic loading of LNG CCS through filling range)
- Vessel strength and fatigue at fixed offshore location for (long) on station design life in harsh environments (e.g. Cyclone areas)
- Cooling water demands uptake and discharge
- Very high Topsides hull turret loads
- Ballast tank hydrostatic head design issues
- Stationkeeping for offloading (tandem or side by side?)
- High mooring interface loads between FLNG and LNGC
- Very HV Power Generation and control voltages beyond normal floating offshore and marine practice
- Fire and Blast challenges
- Dynamic Offloading Systems
- Regulatory issues



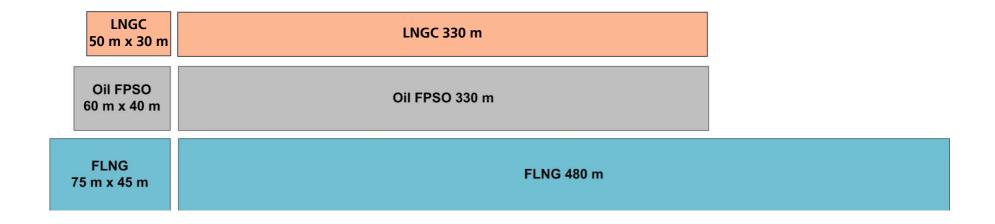
Challenges of Scale



Image courtesy of Shell Australia

- Largest floating offshore facility in the world
- Production from 2 MTPA to in excess of 6 MTPA
- Deck size more than 4 football fields
- Hull/substructure:
 - Deck area equivalent of <u>four</u> typical FPSOs
 - Volume equivalent of <u>eight</u> typical FPSOs
- Topsides facilities four to five tiered modules over the same deck area + accommodation block and turret
- Operating weight is six times largest aircraft carrier
- One quarter size of onshore equivalent plant
- Equipment stacked vertically for space optimisation
- Cargo liquids containment capacity of 175 olympic size swimming pools
- All operating permanently offshore in depths of water from 100 to over 1000 metres

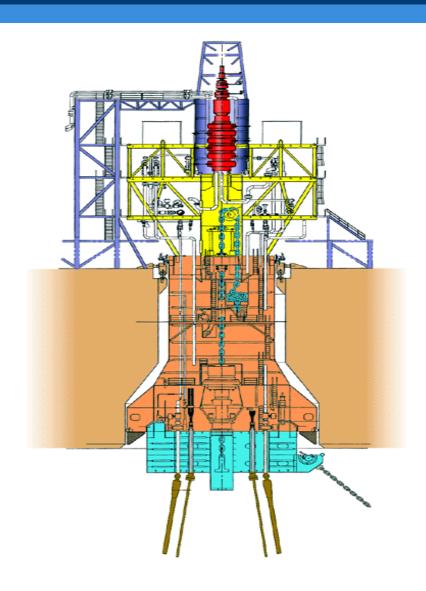
Size and scale versus current practice



Loads due to offshore outfitting

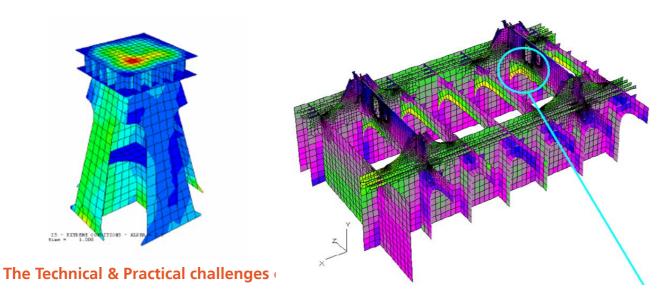
- Turret bearings
- Crane pedestals
- Lifeboat platforms
- Helideck
- Topside plant
- Flare stack

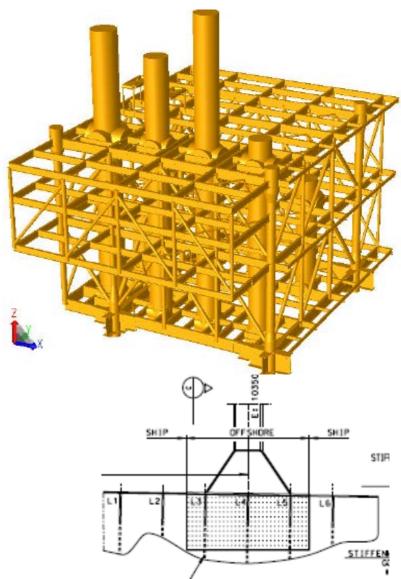




Topsides Layout and Loads

- Oil FPSO topsides up to 40,000 tonnes?
- FLNG topsides up to 90,000 tonnes?
- FPSO Module total typically 4,500t max, static reaction loads up to 1,250t, dynamic 2000t
- FLNG Liquefaction modules total 25,000 to 30,000t, dynamic reaction loads up to 4,000t





Comparison of marine containment systems

Membrane

- No cool-down rate limit.
- Good visibility from bridge
- Space efficient
- Flat deck area is potentially beneficial for FLNG
- Design company available for inservice advice
- Complex Integrity of containment system depends on quality from many sub-contractors
- Potentially vulnerable to partial fillings sloshing damage

Moss

- Less chance of damage by mis-operation
- Primary barrier fully gas-tight
- Visible secondary barrier
- No barred fill ranges
- Easier access for repair
- Expensive build facilities at shipyard
- Domed tanks give poor deck area for FLNG and bridge visibility issues

SPB

- Same as Moss, but:
- Good visibility from bridge
- Flat deck area is potentially beneficial for FLNG
- Prefabricated, possibly offsite
- More space efficient than Moss
- In-service experience limited

Marine LNG Containment Systems suitable for FLNGs

Membrane Systems





Independent Tanks





Prismatic (SPB)

- Stainless steel
- Aluminium alloy (Also used for LPGs)

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Offloading Systems

- LNG
 - Side by side
 - Tandem Overthe-stern
 - Remote
- LPG
 - As LNG
- Condensate
 - Hose reels
 - Floating hoses over- the-stern







Safety aspects - Cryogenics

- Trading gas carriers Only manifold section needs to be considered:
 - Used periodically with loading arms connected and disconnected in benign conditions
- FLNG more complex -LNG rundown into storage tanks and liquefaction processes in constant use and at cryogenic temperatures



ANY QUESTIONS?

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